A public health management model for acute chemical incidents in Wales

Thesis

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A PUBLIC HEALTH MANAGEMENT MODEL FOR ACUTE CHEMICAL INCIDENTS IN WALES

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Declaration

This is to certify that the work submitted is the result of the candidate's own investigation apart from where indicated. None of the work referred to in this thesis has been submitted in support of an application for another degree at this or any other university or institution of learning.

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Abstract

The price of industrial progress is the potential for exposure of an increasingly informed public to chemical hazards in the environment. Of particular concern are acute exposures to chemical incidents, where problematic health risk assessments have highlighted the lack of expertise and resources available to support public health professionals in Wales responsible for protecting the health of populations.

A systematic literature review of chemical incident databases, public health surveillance systems and major chemical incidents worldwide was used to guide the development of the first active, multi-agency community-based public health surveillance system for acute chemical incidents to be undertaken in Europe. A total of 642 acute chemical incidents were reported in Wales from all sources over a three year period. Of the 270 incidents reported by the primary source, chemical spills were the most frequently reported type of incident (28%) and operational industrial sites the most common location (25%). Of the estimated 238,000 people exposed, 528 reported symptoms in a total of 57 incidents. A single chemical was implicated in 86% of the incidents.

Shortfalls were identified in the current expertise and resources available to public health professionals in Wales, leading to the development of a public health management model for acute chemical incidents. Model development took place in the context of United Kingdom - wide initiatives and involved the conduct of structured interviews with 41 organisations with interests in the field. The model selected for Wales was implemented on 1 February 1997 and comprised three levels of operation: (a) accountability for the protection of public health vested in health authorities at the local level; (b) a subscription-based front-line advisory and support unit to those authorities; (c) and a centrally funded national co-ordinating centre to provide the necessary evidence-base through programmes of surveillance, training, and emergency planning.

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Chapter 1 - Introduction

The last fifty years have seen extraordinary advances in chemical technology throughout the world (United Nations Environment Programme 1992). The production of chemical substances has increased exponentially, as have their multifarious uses. More than 600 new chemical substances are believed to enter the marketplace each month (Lillibridge 1997), over 11 million are known and some 60,000 to 70,000 are in regular use (United Nations Environment Programme 1992).

The contribution of the chemical industry to the development of human societies should not be underestimated (McQuaid 1989). Agricultural productivity has improved in both the industrialised world and in many developing countries through the evolvement of chemical fertilisers and pesticides. The clothing industry has become increasingly reliant on synthetic fibres in the manufacture of garments, and the introduction of plastics has revolutionised many sectors of the global economy. Chemicals provide fuels for transport and have been employed in many areas of the construction industry. They have also played a major role in maintaining human health, through the creation of new drugs and pharmaceuticals (United Nations Environment Programme 1992).

However, countering this progress in industrial development is the fact that more people are now at risk of exposure to chemical hazards. With more substances being synthesised, rising production and ever expanding requirements for storage, handling, transport, use and disposal of chemicals, the potential for inadvertent chemical releases has increased, giving rise to greater risks to human health and the environment (McQuaid 1989).

Once released into the environment, chemicals may appear as pollutants of air, food and water. Whether they cause harm to human health will be dependent on the toxicity and physical characteristics of the chemical(s) involved, the concentration, route and duration of exposure and the biological susceptibility of the host (Bertazzi 1989a; Meharg *et al.* 1997; World Health Organisation 1997). In this respect, children, the aged, pregnant women, and those weakened by disease may be more susceptible than the healthy adult (Baxter 1994).

The timing of any adverse health effects after exposure may also vary (World Health Organisation 1997). Acute effects, such as bronchoconstriction and irritation of the skin and eyes, may appear within seconds.

Hours or days later, sub-chronic effects may emerge, for example, delayed pulmonary oedema, but perhaps of most concern to the public and the scientific and medical community are the potential chronic effects on human health, such as cancers and congenital malformations (Haines 1993). It is also important not to forget that mental effects may also arise from real or perceived releases, for example, post-traumatic stress disorder, chronic anxiety and depression (World Health Organisation 1997), and that the environment may also be severely and extensively damaged (Meharg *et al.* 1997).

Any definition of a chemical incident must therefore attempt to embrace all of the above factors. For the purposes of this thesis, the definition used is that of the World Health Organisation (WHO):

> ... an event or occurrence resulting in the release of a substance or substances hazardous to human health and / or the environment in the short or long term. Such events include fires, explosions, leakages or releases of toxic substances that can cause people illness, injury, disability or death.
>
> (World Health Organisation 1997)

Chemical incidents range from common, small-scale releases to full scale disasters (Baxter 1994). However, the size of the problem of chemical incidents remains largely unknown (Bhopal Working Group 1987). Remarkably little formal documentation of chemical incidents has taken place in the United Kingdom (UK) and for that matter anywhere in the world. Whilst many anecdotal accounts of chemical incidents can be found in the literature, as well as commentaries in periodicals and newspapers, accurate statistics are seldom available on the actual numbers of incidents occurring within defined geographic areas, nor information on how well they have been managed (Binder 1989; Baxter 1993; Hall *et al.* 1996).

Occasionally, however, there are disasters. In 1974, a cyclohexane explosion at a petrochemical works at Flixborough in the UK killed 28 persons and injured a further 89 (Department of Employment 1975; Kirkwood 1997). Seveso is still regarded as the prototypal chemical disaster (Bertazzi 1991). The 1976 accident at a trichlorophenol plant near Milan, Italy caused the widespread contamination of several square kilometres of populated countryside with 2,3,7,8-tetrachlorodi-benzo-p-dioxin (Bertazzi 1989a). The accidental release in 1984 of methyl isocyanate gas from a pesticide plant in Bhopal, India, however ranks as the worst industrial disaster in history (Lillibridge 1997). There are still no reliable estimates of the total number dead (observers place it between 6,000 and 20,000) and injured (at least 15,000) (Bhopal Working Group 1987).

Fortunately, such disasters are uncommon, although it is an interesting statistic that between 1980 and 1990, 15 gas releases occurred in the United States (US), which exceeded Bhopal in terms of the quantity and toxicity of the chemicals released (Mukerjee 1995b). However, their very occurrence has led to significant changes in the way members of the public perceive exposure to chemical substances.

Chemical hazards to health have achieved a high public profile (Vale 1994). The often sensational reporting of such disasters by the media has resulted in fear and sometimes panic in populations living close to chemical industries. They are frightening because they have the potential to cause large numbers of deaths and illness and raise questions about the fragilities of technologies over which society, and the local community in particular, have little or no control (Haines 1993). In the US, for example, the Bhopal disaster greatly stimulated local right-to-know movements. Communities demanded to know about chemicals and their health effects, in order that they could participate more effectively in decisions that might affect public health (Bhopal Working Group 1987).

Governmental authorities in many countries now recognise that these concerns need to be faced, both to allay unnecessary fears and to take timely, cost effective action to protect human health and the environment, and to mitigate the deleterious effects of chemical incidents (McQuaid 1989; Haines 1994).

The WHO, in it's Global Strategy for Health and Environment commented that:

> ... at no time before in history have there been so many environmental problems arising which may have an adverse effect on health and with which the health sector must contend,
>
> (World Health Organisation 1992a)

and referring to the Report of the WHO Commission on Health and Environment (World Health Organisation 1992b), it stressed that:

> ... public health professionals should be at the forefront of moves to improve the environment.
>
> (World Health Organisation 1992a)

Chemical incident response actions for public health professionals include coordinating pre-hospital and in-hospital emergency procedures, ensuring access to toxicological information (Lillibridge 1997) and undertaking rapid and complete risk assessments, both of immediate and long-term health effects (World Health Organisation 1997). However, such risk assessments are never easy (Coggon 1995). Inherently subjective, they involve a combination of science and judgement, with psychological, social, cultural and political factors (Slovic 1997). They are also not assisted by the fact that industrial chemicals remain poorly understood (Lillibridge 1997). Of the 70,000 chemical substances in regular use in the world today, adequate toxicology exists for only 2 to 3 per cent (Mukerjee, 1995b).

The inevitable result is that a day or two after an incident, conclusions are drawn by the public and media that politically sensitive data is being withheld by incompetent authorities. The growing activism of workers and community groups around occupational and environmental health issues creates significant challenges and opportunities for the field of public health. Public health professionals often find themselves in an uneasy, even antagonistic, relationship with environmentalists and community activists who react critically to government's performance in investigating and controlling environmental health hazards (Bhopal Working Group 1987).

There is therefore evidence of much public distrust in the individuals that are responsible for health risk assessment (Slovic 1997). The UK approach to managing chemical incidents is principally characterised by the partnership between a number of key players (Home Office 1990; Doig 1995). These include the chemical industry, emergency services, local government, and other agencies. However, responsibility for identifying health problems arising from acute chemical incidents and taking action to remove or mitigate them lies with two principal players, the Environmental Health Departments of local authorities and the Departments of Public Health of health authorities. The former represent the first contact point for members of the public, should they have any concerns regarding the environmental health risks presented by a chemical release, whilst the latter have specific responsibility for coordination of the health aspects of response to chemical incidents (NHS Executive 1993; Welsh Office 1993). This includes ensuring that:

> ... plans are made to respond to public health aspects of incidents relating to non-communicable environmental hazards.
>
> (NHS Executive 1993; Welsh Office 1993)

The ability of health authorities in the UK to cope with chemical incidents has however been questioned (Murray 1990; Baxter 1991; Thanabalasingham *et al.* 1991; Hill and O'Sullivan 1992). The level of preparedness of accident and emergency departments has been found to be variable with regard to training, the provision of protective clothing and the availability of facilities for decontaminating chemically contaminated casualties (Murray 1990; Cooke 1992; Hunter and Mannion 1992). The health professionals within those authorities, normally designated Consultants in Communicable Disease Control (CsCDC), have also been slow to appreciate the health considerations, and the need to work with local authority Environmental Health Officers (EHOs) and the professionals of other agencies in relation to issues of planning, preparedness, response and rehabilitation (Baxter 1991).

This is not surprising given the lack of training that most CsCDC will have received in the toxicological, environmental, epidemiological and clinical aspects of chemical incident management (Hill and O'Sullivan 1992; Lillibridge 1997). Despite the existence of the National Poisons Information Service, and the establishment in 1991 of an independent health advisory group (Health Advisory Group on Chemical Contamination Incidents) by the UK Department of Health (Kennedy *et al* 1994), calls have also been made for the establishment of a national or regional advisory and support network for non-communicable environmental hazards (Baxter 1991; Hill and O'Sullivan 1992; Ayres 1995). The corollary to this is the system already active in the UK for the management of communicable disease control (Palmer 1992).

For communicable disease control in the UK, CsCDC and EHOs are generally familiar with well-established procedures for epidemiological evaluation, outbreak control, and population protection (Palmer 1992). A national laboratory network, the Public Health Laboratory Service (PHLS), also exists to support such professionals in tracing the cause of outbreaks, whilst the PHLS' own Communicable Disease Surveillance Centre monitors infectious diseases both nationally and internationally and employs epidemiologists to assist, when requested, with local investigations. The close collaboration between CsCDC, EHOs and the PHLS is tried and tested and works well.

The situation, however, is very different where the same professionals are faced with a disease for which no infectious origin is clearly evident or with a potential exposure situation arising from the occurrence of a chemical incident. There is no national or regional organisation that can provide a service similar to that of the PHLS.

The aim of this thesis is to consider whether the establishment of such a national or regional organisation for acute chemical incidents is warranted in Wales and, if so, to develop a public health management model for its provision.

Chapter 2 - Methodology

Introduction

In this Chapter, the author will define the concepts and the theoretical framework underpinning the research to be undertaken. Any project relating to public health should take, as its starting point, a systematic effort to specify its current meaning. A complete conceptual development cannot, however, be limited to definitions and therefore a brief discussion is also included on the models that have guided public health. In that the author is developing a new model which, by its very nature, will need to be tested in the practical setting of an acute chemical incident, the underlying methodology has primarily focused on breaking down the barriers that may preclude the utilisation of the research in the decision-making process. The solutions to this potential problem are discussed and definitions provided of a 'model'.

What is meant by public health?

Frenk wrote of public health that:

> ... as a field of knowledge and as a social practice, public health has historically been one of the vital forces that have led to reflection on and collective action for health and well-being.
> (Frenk 1993)

Over the years, public health has been defined in many ways, which when arranged chronologically, present a word picture of the evolution and development of the field (Curran *et al.* 1983). Early definitions limited public health primarily to sanitary measures invoked against nuisances and health hazards outwith the control of individuals, and which, when present in one individual could be communicated to others (Hanlon 1974; Acheson 1998; Editorial 1991). The focus of the public health movement at this time (early to mid-nineteenth century), based on the activities of medical officers of health and sanitary inspectors, was improvements in housing and sanitation standards and the provision of bacteriologically safe water and food (Ashton and Seymour 1991).

The concept of prevention of disease in the individual was then added with the development of techniques for the application of the great immunological discoveries of the early twentieth century (Hanlon 1974). As early as 1920, a comprehensive conception of public health was emerging. In an article published in that year, Winslow stated that:

> ... Public health is the science and art of
> 1. preventing disease
> 2. prolonging life
> 3. promoting health and efficiency through organised community effort for
>   a) the sanitation of the environment;
>   b) the control of communicable infections;
>   c) the education of the individual in personal hygiene;
>   d) the organisation of medical and nursing services for the early diagnosis and preventive treatment of disease, and,
>   e) development of the social machinery to ensure everyone a standard of living adequate for the maintenance of health,
>
> so organising these benefits so as to enable every citizen to realise his birthright of health and longevity.
>
> (Winslow, as cited by Curran *et al.* 1983)

From the 1930s onwards, however, there was a marked shift of power and resources from the public health movement to hospital-based services, culminating in the establishment of the National Health Service in 1948. The problem that was being recognised by governments of all political persuasions by the 1970s was that the demand for treatment services was limitless and that health care costs were rapidly spiralling out of control (Department of Health and Social Security 1976).

A so-called 'new' public health movement therefore emerged at a time of re-evaluation of the effectiveness of therapeutic medicine. A principal protagonist in this debate was McKeown who stated that:

> ... past improvements in health have been due mainly to modifications of behaviour and changes in the environment and it is to these same influences that we must look for further advance.
>
> (McKeown 1979)

In support of McKeown's argument was the political attraction of health promotion, that is, making individuals responsible for their own health (Editorial 1991), and the emergence of a whole new set of diseases - those associated with inequalities in health (Townsend and Davidson 1982; Whitehead 1987), with industrialisation and industrial decline and environmental damage as well as the new infections of human immunodeficiency virus and increasing public concern over food poisoning and meningitis (McPherson *et al.* 1998), none of which could be addressed by curative medicine alone. International direction to the 'new' public health was also provided by the WHOs Health for All by the Year 2000 strategy (European Office of the World Health Organisation 1985), whose targets were adopted by many health and local authorities in the UK. Initiatives included the Healthy Cities Project in Liverpool, where the active participation of individuals and communities was sought in any decisions likely to affect their health, and in taking actions required to make them healthier (Ashton, Grey and Barnard 1986). Efforts were also made to encourage the development of healthy public policy across many areas, including health education in schools; healthy food options and smoke-free areas in restaurants; exercise promotion through town planning and leisure services; healthy work environments, and crime prevention (Ashton and Seymour 1991).

It is therefore not surprising that when the first official inquiry into public health, since the 1871 Report of the Royal Sanitary Commission, concluded its deliberations in 1988 that the definition of public health resembled very closely that of Winslow in 1920, that is:

> ... the science and art of preventing disease, prolonging life and promoting health through organised efforts of society.
>
> (Acheson 1988)

Of the definition, Acheson stated that it gave:

> ... as much weight to the importance of lifestyle as to environmental hygiene in the preservation and promotion of health, and (left) no room for rivalry between preventive and curative medicine.
>
> (Acheson 1988)

The US Institute of Medicine in its report on the "Future of Public Health", which was also published in 1988, provided an equally authoritative definition:

> ... public health is what we, as a society, do to assure the conditions for people to be healthy.
>
> (US Institute of Medicine 1988)

In the 1990s, the pendulum has also swung back to the environmental approaches to public health which were so successful in the nineteenth century (Draper 1991). Draper in his book on "The greening of public health" states that:

> ... the core of public health action is avoiding or countering hazards in the environment, from the physical, chemical and biological to the socio-economic.
>
> (Draper 1991)

This new environmental public health, however, has a broader outlook, with the increasing recognition of the interdependence of ecosystems and health systems, which has fostered concepts such as "sustainable development", where improvements in health standards are only genuine when the resources used in their achievement can be renewed (Ashton 1991).

Bringing the discussions up to date, 1997 witnessed the appointment of Britain's first minister of public health, a sign that the new Labour administration recognises that the health of the population depends on more than the provision of good healthcare services (Olsen 1997). With the government's stated commitment to public health, a likely catalyst to improving the population's health in the new millennium could well be the practice of "health impact assessment". The subject of a recent report of the British Medical Association Board of Science and Education, health impact assessment provides a means of identifying, predicting and evaluating the likely positive and negative changes to health arising from any future policies, programmes or projects (British Medical Association 1997). This means those introduced by all government departments, not just the Department of Health.

Conceptual Models in Public Health

From the above discussion, it is evident that the essence of public health is that it adopts a perspective based on groups of people or populations. This contrasts with clinical medicine, which operates at an individual level, and biomedical research, which analyses the sub-individual level. This population perspective inspires the two facets of public health: as a field of inquiry - public health research - and as an arena for action - the practice of public health (Frenk 1993).

Public Health Research

To help visualise the role of public health within the more general field of health research, Frenk *et al.* developed the typology shown in Table 2.1.

Table 2.1 **Typology of Health Research, with Examples of Phenomena to be Studied**

LEVEL OF ANALYSIS	OBJECT OF ANALYSIS	
	Conditions	**Responses**
Individual and Subindividual	*Biomedical Research* (Basic biological processes; structure and function of the human body; pathological mechanisms)	*Clinical Research* (Efficacy of preventive, diagnostic, and therapeutic procedures; natural history of diseases)
Population	*Epidemiological Research* (Frequency, distribution and determinants of health needs)	*Health Systems Research* (Effectiveness, quality, and costs of services; development and distribution of resources for care)

Source: Frenk 1993

For the objects of analysis, conditions were defined as:

> ... the biological, psychological and social processes that constitute the levels of health in a given individual or population

and response as:

> ... the external response that society organises for improving health conditions.
> (Frenk *et al.* 1988)

The second dimension reflects the two different levels of analysis: individual and sub-individual, and population. Crossing these two dimensions are the three principal types of research that characterise the health field, namely: biomedical, clinical and public health, with the latter differentiated into epidemiological research and health systems research. A criticism aimed at this typology is that it identifies each level of analysis with a given discipline. The fact is that the biological sciences, for example, the toxicological analysis of environmental risks, may be just as essential to public health as the social sciences (Frenk 1993). Interdisciplinary integration is therefore an essential prerequisite to the concept of public health (Acheson 1988).

The Practice of Public Health

As stated above, public health is also an arena for action. As Frenk states:

> ... it addresses the systematic efforts to identify health needs and organise comprehensive services with a well-defined population base.
>
> (Frenk 1993)

In this respect, the Acheson report provided a detailed account of the development of the public health function in England (which is equally applicable to Wales), and fashioned a role for the specialty of public health medicine at the forefront of health authorities' service planning (Acheson 1988). Health authorities were required to ensure effective arrangements for control of infection, prevention of disease, and promotion of health, and to appoint a named leader of the public health function in their respective districts, to be called Directors of Public Health (DsPH). DSPH were, in turn, required to assess health needs and produce annual reports on the health of the population.

The compelling need for greater collaboration between health authorities and local authorities was also highlighted in the Acheson report, with a specific recommendation that:

> ... the DPH and Chief Environmental Health Officer (CEHO) should meet on a regular basis and ... establish channels of communication which encourage collaboration.
>
> (Acheson 1988)

Additionally, the important input of other non-medically qualified practitioners was recognised, for example, nurses, health promotion officers, statisticians, health economists and town and country planners. The complex guidance (Department of Health 1993) that was later issued on these relationships was, however, criticised as not having even started to break down the professional barriers to such collaboration (Harris and Shapiro 1994). Intersectoral collaboration is therefore another essential prerequisite to the concept of public health, the importance of which will become increasingly evident in subsequent chapters.

Models of Public Health

Frenk, however, went further in his analysis of the new public health, by using the distinction between the afore-mentioned objects of analysis, that is, conditions and responses, to identify the principal conceptual models that have guided public health. The former are analysed from two main perspectives: health and disease, whilst responses are directed at different objects of intervention, namely the individual, including his or her immediate family surroundings, and the environment, which is subdivided into biological and physical components, and social components.

Table 2.2 Main Conceptual Models on Public Health

SOCIAL RESPONSE: OBJECTS OF INTERVENTION	**CONDITIONS: ANALYTICAL PERSPECTIVES**	
	Health	**Disease**
Individual/Family	Hygienist/Preventative Model	Biomedical Model
Biophysical Environment	Sanitarist Model Ecologist Model	Classic Epidemiologic Model
Social Environment	Sociomedical Model	Social Epidemiologic Model

Source: Frenk 1993

Crossing these two dimensions produces the typology of models shown in Table 2.2. The names given to the models correspond to the history of public health, much of which has already been described earlier in this Chapter. For example, the "hygienist/preventative" model was initially developed in the nineteenth century, when there was a movement to instruct the family in a series of behavioural rules that defined a "healthy life". This model was displaced by the "biomedical model", which brought the control of specific diseases to the centre of public health concerns, but eventually reappeared in programmes aimed at changing individual behaviours and lifestyles as the basis of the strategy of health promotion. Public health can therefore be characterised by a wealth of intellectual traditions, each implying a particular programme of development for acquisition of knowledge and for action.

Model Development in Practice

As will be evident from the above discussion, models are constructed representations of aspects of our environment; they use concepts as the building blocks (Polit and Hungler 1993). As Treece and Treece state:

> ... model is a conceptual idea, formulated in the mind or on paper, that diagrams or explains a situation in real life.
>
> (Treece and Treece 1986)

Although the terms are often used interchangeably (Bell 1993), models differ from theories in that they provide a visual or symbolic representation of a conceptual framework that, as Polit and Hungler state:

> ... helps to express abstract ideas in a more readily understandable or precise form than the original conceptualisation.
>
> (Polit and Hungler 1993)

Several types of models are referred to in the research literature (Treece and Treece 1986). However, for the purposes of the author's research, the concepts and phenomena under study will be presented as schematic models, that is, the concepts and linkages between them will be represented diagramatically through the use of boxes, arrows and other symbols. The perceived advantage of this approach is summarised by Polit and Hungler, who state that:

> ... schematic models can be useful in the research process in clarifying concepts and their associations, in enabling researchers to place a specific problem into an appropriate context, and in revealing areas of inquiry.
>
> (Polit and Hungler 1993)

Most researchers tie their studies to an existing conceptual model or theory. The author's intention, however, is to knit together findings from a comprehensive literature review of previous research in the study area (Chapter 3), together with surveillance of acute chemical incidents (Chapter 5) and structured interviews of key personnel of UK organisations working in the field (Chapter 6), to form the basis for the development of his own conceptual model (Chapter 7), which will then be evaluated (Chapter 8) and appropriate conclusions drawn (Chapter 9).

Linking Research to Decision-Making

In investigating both the terminology and conceptual models of public health, it has been demonstrated to be a deeply social as well as a scientific discipline, and because of the complex nature of its interests and responsibilities, a highly politicised one. Curran *et al.* state of its duties and responsibilities that:

> ... all ... are discharged in the pressure cooker of public life, which is constantly fuelled by a variety of often contentious power bases ... the political structure, news media, regulatory agencies, the scientific community, industry, special interest groups and the public at large.
>
> (Curran et al. 1983)

Added to this is the fact that all actions and decisions must be made in the full view of any interested parties.

It was therefore recognised, at an early stage, that the main barriers to the development of a public health management model for acute chemical incidents in Wales would be rooted in the different kinds of logic and demands that the author, as the researcher, and the "decision-makers" faced in their respective areas of activity. By "decision maker" is meant any person who makes a decision to determine a course of action in response to a given health problem, and might include Welsh Office policy makers, DsPH of health authorities and CEHOs of local authorities.

To ensure that the research undertaken was relevant to decision-making, solutions were sought to overcome the potential barriers highlighted in Table 2.3. The first potential conflict relates to the definition of priorities. In this respect, the author was always conscious of the danger that the decision-makers might end up with a very different perception of the practical benefits of the research than himself, making implementation of the final model and its testing impossible. To surmount this barrier, every effort was therefore made to ensure the presence of decision-makers in the management of the research undertaken, so that they could express their needs and identify opportunities for themselves and their respective organisations. As Frenk rightly states:

> ... decision-makers must be "informed consumers" of research products.
>
> (Frenk 1993)

Table 2.3 **Sources and Solutions of Possible Barriers between Researchers and Decision-Makers**

POTENTIAL BARRIERS BETWEEN RESEARCHERS AND DECISION MAKERS	MEANS OF OVERCOMING THE BARRIERS
1. Priorities	- Education of "informed consumers" of research - Presence of decision makers in the governing or advisory bodies of research institutions
2. Time management	- Collaboration between researchers and decision makers since the planning stage of projects - Identification of intermediate products of research
3. Language and accessibility of results	- Executive summaries - "Translators" of research to policy - Joint seminars for discussing results
4. Perceptions about the final product of research: discovery vs. decision	- Explicit utilisation objectives together with production-of-knowledge objectives
5. Integration of different findings on the same problem	- Meta-analysis - Mission-oriented research

Source: Frenk 1993

The second barrier reflects the real differences between political timescales and scientific timescales, as will become increasingly evident in the later Chapters on model development and model selection. In general, time is one of the principal enemies of decision-makers. The author, however, was keen to allow for the full expression of the processes under study. This barrier was again overcome by an ongoing process of collaboration between the author and decision-makers, enabling negotiation and agreement on the time frames required for producing useful results. At all stages of the research, the author also offered intermediate products, such as progress reports, which were useful for decision-making, in advance of any of the component areas of the research being completed.

Another set of important differences has to do with the language and accessibility of results. Whilst the results are presented in precise terms for the purposes of this thesis, the author has also sought to regularly translate the findings into recommendations for policy and action, in a language understandable to decision-makers. For example, for the surveillance (Chapter 5) and model development (Chapter 6) parts of the research, executive summaries have been produced and joint seminars and meetings held where the author has discussed the results with various decision-makers.

A fourth potential barrier is represented by the fact that for the decision-maker, research cannot be said to have come to a proper conclusion until it has influenced a decision. To overcome this barrier, in the initial formulation of the research proposals, objectives were also set for applying the results. In this way, the need for utilisation of the knowledge gained became a programmed phase of the research process.

Finally, there is the problem of integrating the different results and information, so as to enable the decision-makers to assess all the dimensions of the same question and make a decision. As Frenk states:

> ... in applied fields (such as the management of acute chemical incidents), decision-makers face complex problems on which they demand comprehensive information, but scientific knowledge is provided to them in small parcels that are very difficult to aggregate.
>
> (Frenk 1993)

For this reason, the methodology employed has been based on the philosophy of "mission-oriented research". The latter is based on integration along three dimensions: levels of analysis, objects of analysis and disciplines. The first two dimensions have already been considered (see Figure 2.1). Neither would, however, be possible but for the third dimension, that is, the integration of disciplines. This was seen from the outset to be the key to the development of the author's research: the interaction of public health research with biomedical research, clinical medicine, and the social sciences; and the interaction of public health doctors with environmental health officers, policy makers, toxicologists, epidemiologists, chemists, occupational hygienists, emergency planners, emergency responders and other professionals.

The advantages of such a mission-oriented approach are that complete information on any problem can be assimilated quickly, because knowledge is integrated at the planning stage; the practical implications of the research can be identified and translated into action more readily; setting priorities and forming groups is easier, as is the financing of research; and, interinstitutional and multicentric collaborations become the norm (Frenk 1993).

Conclusion

Through reviewing the development of the intellectual field of public health, a theoretical framework for the research has evolved. This is primarily based on the need identified to establish dynamic and creative linkages between the results of the research and public health decision-making in the field. The framework also provides a basis for the evaluation of the model developed. The bottom line is that the research would not have been possible had the results not been capable of being put into practice by public health professionals attending the scene of an acute chemical incident and or providing advice and support on the public health aspects of such incidents.

Chapter 3 - Literature Review

Introduction

Chemical incidents are regarded as a major public health problem (Binder and Sanderson 1987; Lechat 1990; Lillibridge 1997). However, on what basis is such a statement made? This Chapter will therefore start by investigating the public health relevance of existing sources of data on chemical incidents worldwide, including special surveys and surveillance systems, in order to provide guidance for the development of a system for better defining the size of the problem of acute chemical incidents within the principality of Wales (Chapter 5).

A review of the general literature on acute chemical incidents will then be presented to help ascertain the types of incidents and challenges facing public health professionals. It is not intended for this to be a practical guide to the public health aspects of response to acute chemical incidents, as there are already a number of excellent texts in the area, for example, the joint publication of the International Programme on Chemical Safety (IPCS), the Organisation for Economic Co-operation and Development (OECD), the United Nations Environment Programme (UNEP) and the World Health Organisation (WHO) (OECD 1994). The lessons learned from the review will, however, provide a framework for analysis of the data gained from the surveillance system developed in Wales.

Method

A systematic literature search for published documentation on chemical incident databases, public health surveillance systems for acute chemical incidents, public health surveys of acute chemical incidents, and individual reports of acute chemical incidents was undertaken. The original intention was to cover world literature from 1945. In practice, however, the sources of information available were not sufficiently comprehensive and their coverage was mainly of work published in English since 1980.

Literature searches were made of library catalogues, bibliographies, abstract indexes, external on-line databases, scientific and news journals and worldwide web sites (Table 3.1). Personal contact was also made with a wide range of national and international bodies, the latter including IPCS, OECD, and the United States Agency for Toxic Substances and Disease Registry (ATSDR).

A small number of search terms were developed for identifying chemical incident databases, public health surveillance systems for acute chemical incidents and public health surveys of acute chemical incidents, as shown in Table 3.1. A public health surveillance system was distinguished from a public health survey, on the basis of the traditional definition of "surveillance", that is, the ongoing and systematic collection, analysis and interpretation of data on specific health events affecting a population, closely integrated with the timely dissemination of information to those responsible for prevention and control (Centers for Disease Control 1988). In contrast, public health surveys were considered to be one-off studies.

The search for reports of acute chemical incidents was intentionally biased towards those giving rise to community exposures. Details of the criteria used in selecting incidents for inclusion in the review are provided in Table 3.2. The most difficult task was to translate the "criteria for inclusion" into search terms which were sufficiently tightly defined to identify acute chemical incidents, whilst at the same time producing a manageable number of entries. It was also recognised that a framework was needed for classifying the incident data, to obviate any criticisms of the conclusions drawn from any analyses undertaken (McQuaid 1989). A proforma was therefore developed for this purpose (Appendix 3.1).

The report which provided the most complete information on an incident was selected as the primary source. However, checks were made on the consistency of information reported on incidents, where they appeared in more than one source. Where undertaken, the accuracy of information, for example, on deaths, injuries and evacuations, and on the chemicals involved was found to vary, confirming the findings of previous studies (Binder 1989).

On selection of the primary source, the incident data was classified in accordance with the proforma developed, and entered into a Microsoft Access (v.7) database to facilitate analysis. Information entered included the date, country, location and nature of the incident; details of the chemical(s) released; and statistics on the public health consequences, in terms of deaths and injuries by population group, evacuation details, and the prevalence of epidemiological studies.

Table 3.1 Sources of Literature Reviewed and Search Terms Used

ON-LINE DATABASES	DATES OF PUBLICATION
MEDLINE	1955 - 1997
TOXLINE	1981 - 1997
HSELINE	1981 - 1997
ENVIRONMENTAL DATA SERVICES REPORTS	1992 - 1997
BIDS ISI DATA SERVICES LTD	1992 - 1997
POLLUTION ABSTRACTS	1992 - 1997

SEARCH TERMS for ON-LINE DATABASES			
First Word	Second Word	First Word	Second Word
Accident &	Chemical Environmental Industrial Toxic Hazardous Substances Transportation	Fire &	Chemical Industrial Warehouse
Incident &	Chemical Environmental Industrial Toxic Hazardous Substances Transportation	Explosion &	BLEVE Chemical
Disaster &	Chemical Environmental Industrial Toxic Hazardous Substances Transportation	Waste &	Chemical Toxic Industrial Hazardous
Pollution &	Chemical Environmental Industrial Water Soil Marine	Contamination &	Chemical Water Food Soil
Leak &	Chemical Toxic & Gas Gaseous Hazardous Substances	Epidemiology (-ical) &	Study (-ies)
Release &	Chemical Toxic & Gas Gaseous Hazardous Substances	Surveillance & Survey & Database &	Chemical Incident Chemical Disaster Chemical Accident Epidemiological Public Health Hazardous Substances Events
Spill &	Chemical Oil Transportation Hazardous Substances		

ABSTRACTS	DATES OF PUBLICATION	SEARCH TERMS
Excerpta Medica - Environmental Health and Pollution Control	1987 –1997	Effects of Pollution on Man
Pollution Abstracts	1980 – 1992	Environmental Hazards
BIBLIOGRAPHIC JOURNALS	**DATES OF PUBLICATION**	**SERACH TERMS**
WASTE AND ENVIRONMENT TODAY	1991 – 1997	Environmental Hazards
NEWS JOURNALS		
WASTE AND ENVIRONMENT TODAY	1991 - 1997	Environmental Hazards

Table 3.2 Search Parameters

Language	English
Geography	World
Time Period	1945 - 1997
Criteria for inclusion of "Acute Chemical Incidents"	a) An uncontrolled, illegal or threatened release of a chemical substance(s); b) The release must have resulted in ill-health or had the potential to cause ill-health (defined by reference to deaths, injuries and/or evacuations); c) Members of the community must have been exposed or been at risk of exposure; d) The release must have necessitated the immediate mobilisation and organisation of the emergency services and other supporting organisations.
Sources	See Table 3-1 above
Search Terms	See Table 3-1 above

Results

Chemical Incident Databases

A total of 9 chemical incident databases were identified through the literature search (Table 3.3). Six of the databases had been established to meet explicit legislative requirements. Four of these were based in the United States (US) (Binder 1989; Wendt and Hall 1996) and one in Finland (Laitenan and Tech 1988). The remaining database of this type and the only one applicable to the UK was the Major Accident Reporting System (MARS), established under the provisions of European Community law, to receive notifications from member states of major chemical accidents occurring at specified industrial sites within their respective territories (Health and Safety Executive 1990; Kirchsteiger 1997). The other 3 databases had been set up for primarily commercial reasons. Both the Major Hazard Incident Data Service (MHIDAS) (AEA Technology 1994) and the Failure and Accidents Technical Information System (FACTS) (TNO 1992) collected information on chemical accidents on a global basis, drawing their information from a variety of sources, including the media. The Environmental Incident Database Service (EnviDAS) did likewise, but focusing only on environmental impacts (Meharg *et al.* 1997).

On closer inspection, it is however clear that these databases, whilst holding information on many thousands of incidents, focus mainly on the causes and the immediate losses. They therefore serve primarily to guide risk assessment decisions in relation to major hazard planning and management (Tandon, Winder and Mifflin 1989; TNO 1992). All have limitations when it comes to quantifying health consequences in the post-incident phase (Binder 1989; Bertazzi 1989a; Hall *et al.* 1996). For example, the accuracy of death and injury information is questionable, with little or no validation of the data. This makes analysis of any association between mortality and morbidity, and risk factors, such as location of incident, virtually impossible (Binder 1989).

Additionally, only acute health effects are covered, despite concerns about the potential long-term health effects of chemical incidents and the psychological impact of releases and evacuations (Haines 1993; Hall *et al.* 1996; Mitchell 1996; Shaw, Windham, Leanoard and Neutra 1986); neither is information available on exposure levels (Meharg *et al.* 1997).

Given the well-recognised discrepancy between the number of incidents that actually occur and those that are recorded, such collections of data are also far from exhaustive (TNO 1992). In a review of three of the afore-mentioned US' systems, Binder reported the shortcomings of any single national reporting source when trying to assess both the number and effects of chemical incidents. Of the 587 incidents reported to these three national databases during the study period, only 8 appeared in all three systems. This was attributed to the different areas of emphasis of each database and the failure to report by responsible parties (Binder 1989).

In spite of these criticisms, many still consider such databases to be a useful tool with which to awaken people to the extent of the problem (Bertazzi 1989a).

Public Health Surveillance Systems for Acute Chemical Incidents

Only two current geographically defined surveillance systems were identified, both initially by personal communication. Two other systems were identified in the scientific literature, although neither were still operational.

The first of the current systems was the Hazardous Substances Emergency Events Surveillance System (HSEESS), maintained by the US ATSDR (Binder and Bonzo 1989; Jones *et al.* 1993). Further to the shortcomings identified by Binder in her review of US chemical incident databases (see above), the US ATSDR decided to develop an active state-based system to better determine the public health consequences associated with hazardous substances releases. Implemented on 1 January 1990, the system had expanded its coverage to nine US states by 1992. Within each participating state, at least one full-time member of staff was employed to actively investigate all hazardous substances releases. Sources of information included the personnel and records of state environmental agencies, local emergency planning committees, fire and police departments, and hospitals. Incident reports were collected on standardised data collection forms, including information on the event, chemical(s) released, deaths, injuries and evacuations. On collection, the data was computerised using an ATSDR provided data entry system, and sent to the agency on a quarterly basis. Hazardous substances emergency events were defined as uncontrolled or illegal releases of substances or their hazardous by-products. Not included were events involving petroleum products exclusively.

Table 3.3 **Chemical Incident Databases (Adapted from Meharg *et al.* 1997)**

Database	Acronym	Agency	National / International	Primary Data Sources
Major Hazard Incident Data Service (AEA Technology 1994)	MHIDAS	UK Health and Safety Executive (HSE)	International	Compiled from literature and media reporting
Environmental Incident Database Service (Meharg *et al.* 1997)	EnvIDAS	UK HSE	International	Compiled from literature and media reporting
Major Incident Reporting System (Kirchsteiger 1997)	MARS	Commission of the European Communities	European	Events that are deemed to be major incidents under the Seveso Directive
Emergency Response Notification System (Wendt and Hall 1996)	ERNS	US Environmental Protection Agency (EPA)	US	Reported by government agencies
Acute Hazardous Events Database (Binder 1989)	AHE	USEPA	US	Reported by government agencies
Failure and Accidents Technical Information System (TNO 1992)	FACTS	TNO Environmental and Energy Research	International	Compiled mainly from literature, periodicals, newspapers, technical reports and other publications
Hazardous Materials Information System (Binder 1989)	HMIS	US Department of Transportation (DOT)	US	Events that are deemed to be legally reportable by carriers
National Response Center Database (Binder 1989)	NRC	US Coastguard Agency	US	Events that are deemed to be legally reportable by responsible parties
Technical Inspection Centre Database (Laitenen and Tech 1988)	Not Applicable	Technical Inspection Centre, Finland	Finland	Events that are deemed to be legally reportable by responsible parties

A later publication on HSEESS has revealed that a total of 3125 hazardous substances releases were reported from 1 January 1990 to 31 December 1992 (Hall *et al.* 1996). During 467 (15%) of these releases, 1446 people were injured. Most releases (77%) occurred at fixed facilities, and 23% were transportation-related. The substances most frequently involved in releases with public health consequences were acids, ammonia, pesticides and volatile organic compounds. The HSEESS was particularly instructive in terms of the benefits of employing an active system of surveillance, and also in identifying factors to be considered in the design of appropriate data analysis routines.

The second current system was based in Scotland (Forbes 1993). A national unit to support local health professionals in the investigation of environmental health issues had been established in 1989 - the Environmental Health (Scotland) Unit. The "Environmental Health Incident Notification System" was a voluntary programme, with a broad aim: "to record all incidents, of whatever nature, which adversely affect environmental health". The system was reliant on notifications of environmental incidents from all the various response organisations within Scotland. Following discussions with these organisations, the types of incident to be recorded were:

> ... *those of an unusual, serious or difficult nature and those which were long-standing and unresolved.*
>
> (Forbes 1993)

Notification of an incident could either be made in writing or via the telephone. Information recorded included the name of the notifying organisation, the date, nature and other brief details of the incident, and any assistance required. On average, approximately 400 notifications per year were received, although no further breakdown was provided. A design feature emphasised by Forbes as being critical to the success of the programme was the need to:

> ... pass information back so that everyone can learn from the problems, errors or the *investigations undertaken.*
>
> (Forbes 1993)

The two other systems identified by the review both involved the ongoing and systematic collection of incidents by fire brigades over periods of one year and six months respectively. The most comprehensive was that undertaken by the UK fire service in 1980 to determine the numbers and characteristics of dangerous chemical incidents handled by their employees (Maclean 1981). The system was based on a self-completion questionnaire, which all brigades were asked to complete for each chemical incident to which they were called during the period 1 January to 31 December 1980. The system developed had many excellent design features, including piloting of the proposed questionnaire and three stages of data validation. Over the twelve month period, a total of 1158 incidents were reported, which equates to 3.3 chemical incidents per day in the UK. The most frequently reported incidents were chemical spillages (43%), leakages (22%) and fires (18%). However, a surprising finding for the researchers was that 16% of the incidents were identified as arising from chemicals being washed ashore around the coast. The incidents reported were further classified by time of year and day, chemicals involved, protection and decontamination issues and the numbers of casualties. Overall, a total of 5 fatal and 681 non-fatal casualties were recorded in 173 (15%) incidents. However, only 4% of the incidents resulted in casualties which were sufficiently serious to warrant treatment.

The second fire service system involved a six-month surveillance study of chemical incidents handled by brigades in Australia (Winder *et al.* 1992). The system identified 523 incidents, most commonly spillages and leakages.

Public Health Surveys of Chemical Incidents

Two surveys were identified by the review, one in the scientific literature, the other through personal communication with the authors concerned. The former was a report of research undertaken into the frequency and causes of evacuations associated with chemical accidents from 1980 through 1984 (Sorensen 1987). The primary source of data was national, regional and state wire service coverage of accidents in the United States. Using an automated search of a commercial database of newspapers and periodical publications, 300 accounts of evacuations were identified. The evacuations ranged in size from two households to 30,000 people, mainly originated at fixed facilities or following train derailments and resulted in 2051 injuries and one death. However, concerns were expressed in the report regarding the accuracy of the data contained within newspaper coverage of chemical accidents.

The second survey identified will be presented in Chapter 4, as its broader findings are used to set the context for the development of a surveillance system for acute chemical incidents in Wales (Chapter 5).

Reports of Acute Chemical Incidents - General

<u>Sources of Incident Reports</u>

A total of 493 reports were obtained, covering 369 incidents. The most productive source of information on incidents was HSELINE (34%), followed by the hand search of key journals (21%) and the review of European Reports (14%) (Figure 3.1). Seventy-five per cent of incidents were identified from a single source, suggesting little overlap in the reporting of specific incidents by the various sources used. For example, of the 206 reports identified through on-line searching of MEDLINE, TOXLINE and HSELINE for the period 1981 - 1997, only 9 incidents were common to all three systems (Figure 3.2).

The latter finding may be explained by the differences in source materials for the three databases. Incident reports identified within HSELINE were mainly drawn from news journals. In contrast, scientific peer-reviewed journals provided much of the source materials on incidents within MEDLINE and TOXLINE (Figure 3.3). For the 369 incidents identified by the review, only 81 (22%) were published in scientific peer-reviewed journals. The most common sources of information on incidents were the anecdotal accounts of news journals (45%), followed by summaries of incidents provided within published reports (23%). The quality of information contained within most reports was therefore questionable and, for this reason, the following analysis of incidents must be interpreted with caution.

Figure 3.1 Sources of identification of 493 reports of chemical incidents

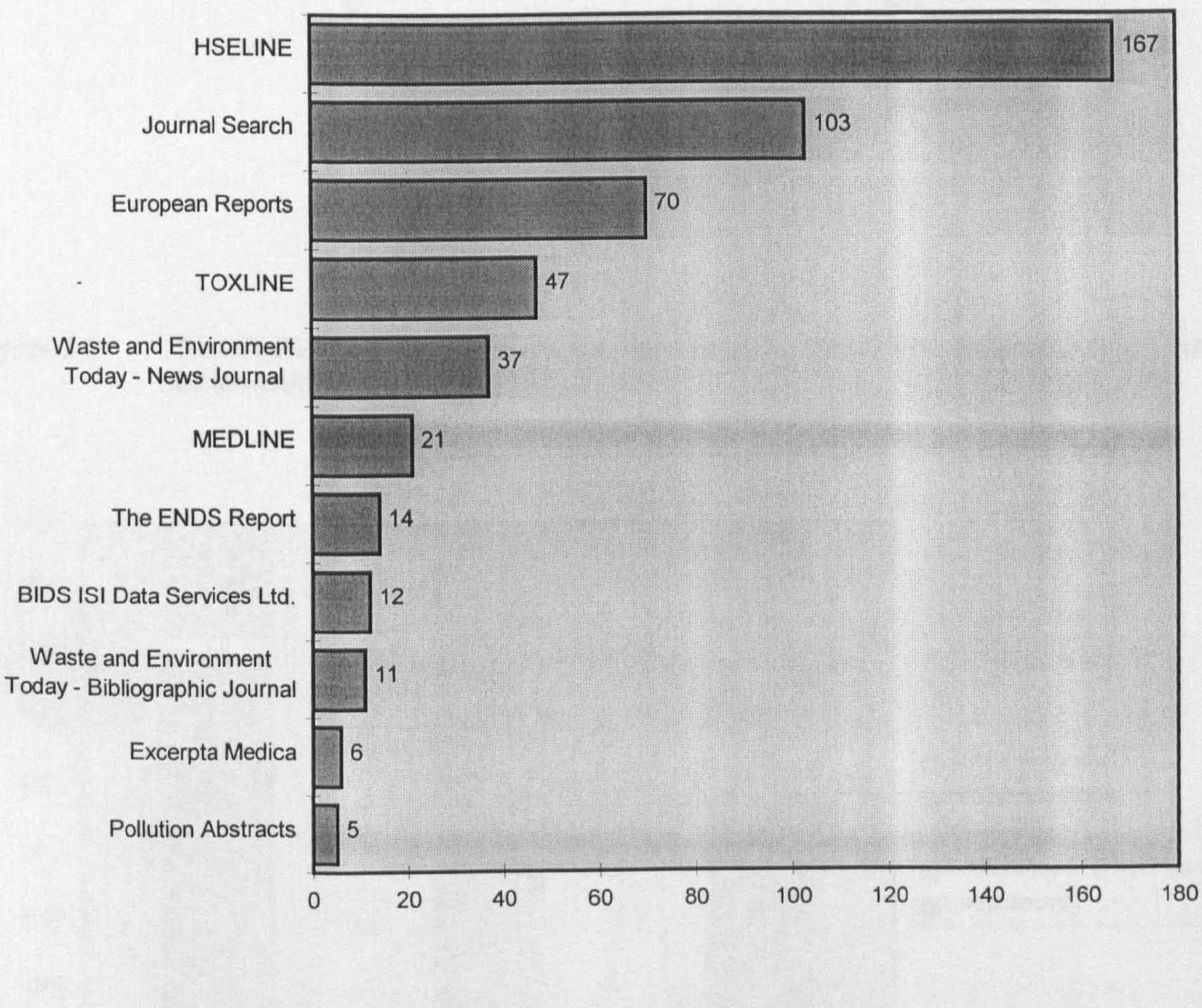


Figure 3.2 Distribution of 206 chemical incident reports, by on-line database 1981 -1997

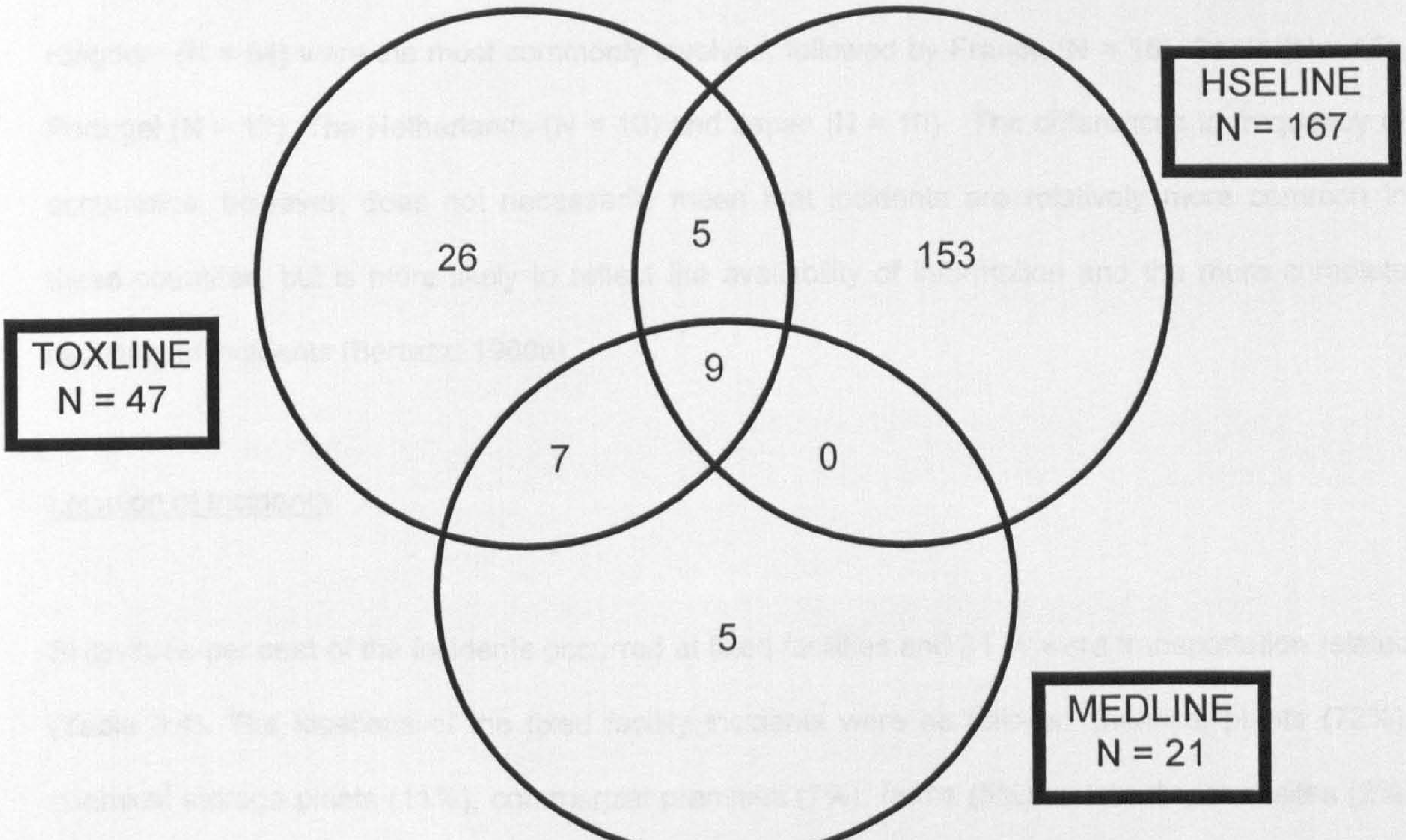
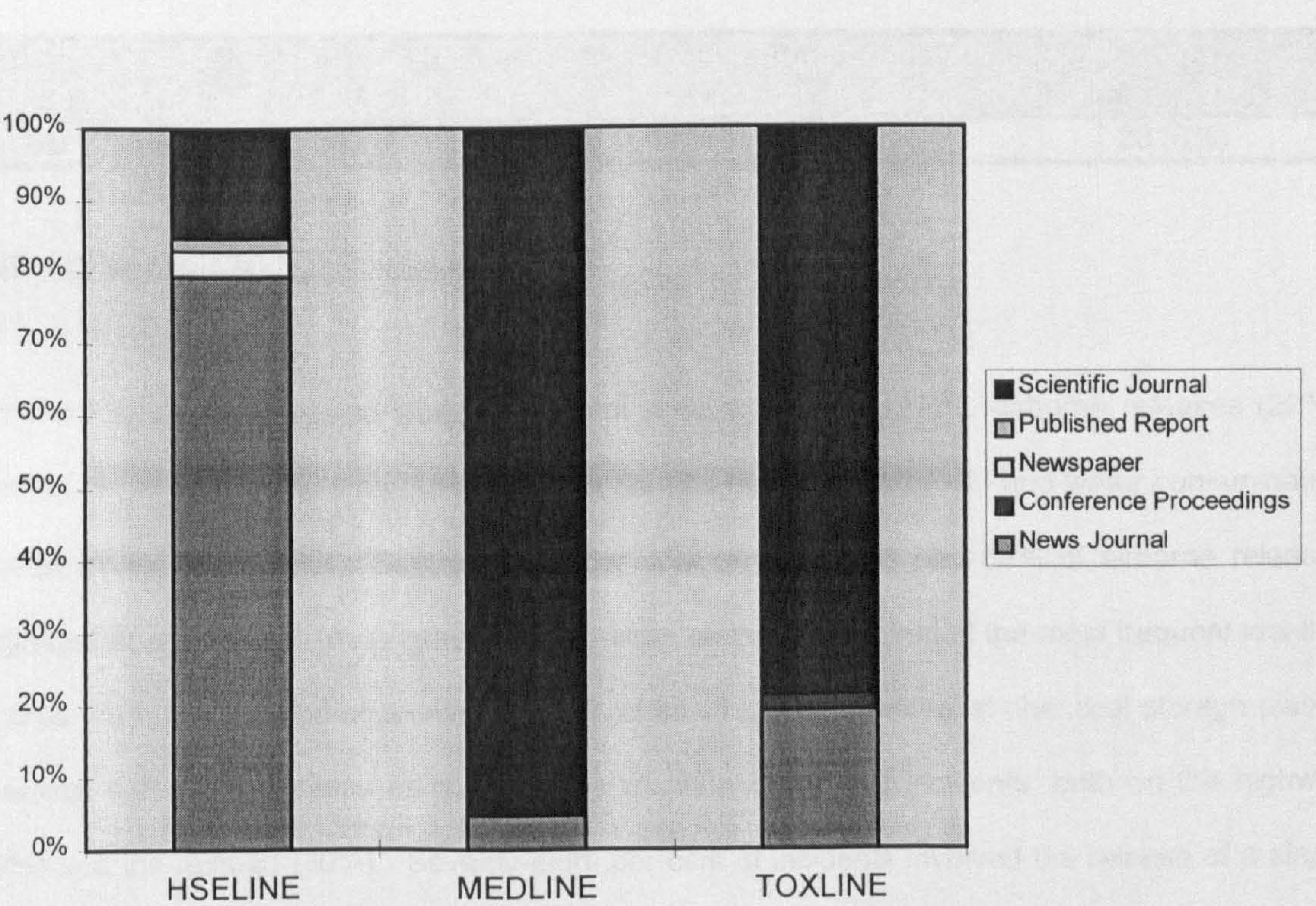


Figure 3.3 Distribution of 206 chemical incident reports, by on-line database and source of identification 1981 - 1997



Country of Incident Location

Of the 50 countries in which incidents were recorded, the United States (N = 100) and the United Kingdom (N = 84) were the most commonly involved, followed by France (N = 16), Spain (N = 15), Portugal (N = 12), The Netherlands (N = 10) and Japan (N = 10). The differences in frequency of occurrence, however, does not necessarily mean that incidents are relatively more common in these countries, but is more likely to reflect the availability of information and the more complete reporting of incidents (Bertazzi 1989a).

Location of Incidents

Sixty-three per cent of the incidents occurred at fixed facilities and 31 % were transportation related (Table 3.4). The locations of the fixed facility incidents were as follows: chemical plants (72%), chemical storage plants (11%), commercial premises (7%), farms (5%), waste disposal sites (2%) and water treatment works (3%). Of the transportation incidents, 41% involved transport by rail and 32% occurred on the highway. The remainder involved transport at sea (18%) or by pipeline (9%).

Table 3.4 Classification of 369 chemical incidents according to location

Cause	Fixed facilities	Transportation-related	Other
Number (Percentage)	233 (63%)	113 (31%)	23 (6%)

Nature of Incidents and Chemicals Involved

The most frequently reported types of incident were explosions (27%), airborne releases (22%), chemical spills (20%) and fires (15%). The remainder included food (6%) and water contamination incidents (4%) (Figure 3.4). Seventy-three per cent of explosions and 59% of airborne releases originated at chemical plants (Figure 3.5). Likewise, such plants provided the most frequent location for fires (46%). Fires also accounted for 72% of all incidents occurring at chemical storage plants. Chemical spills arose mainly as a result of transportation-related incidents, both on the highway (29%) and the railroad (30%). Seventy-eight per cent of incidents involved the release of a single chemical (Table 3.5). A total of 197 different chemicals were released in the incidents recorded. Those chemicals most frequently involved were acids, pesticides, chlorine and ammonia.

Figure 3.4 Distribution of 369 chemical incidents, by nature of incident

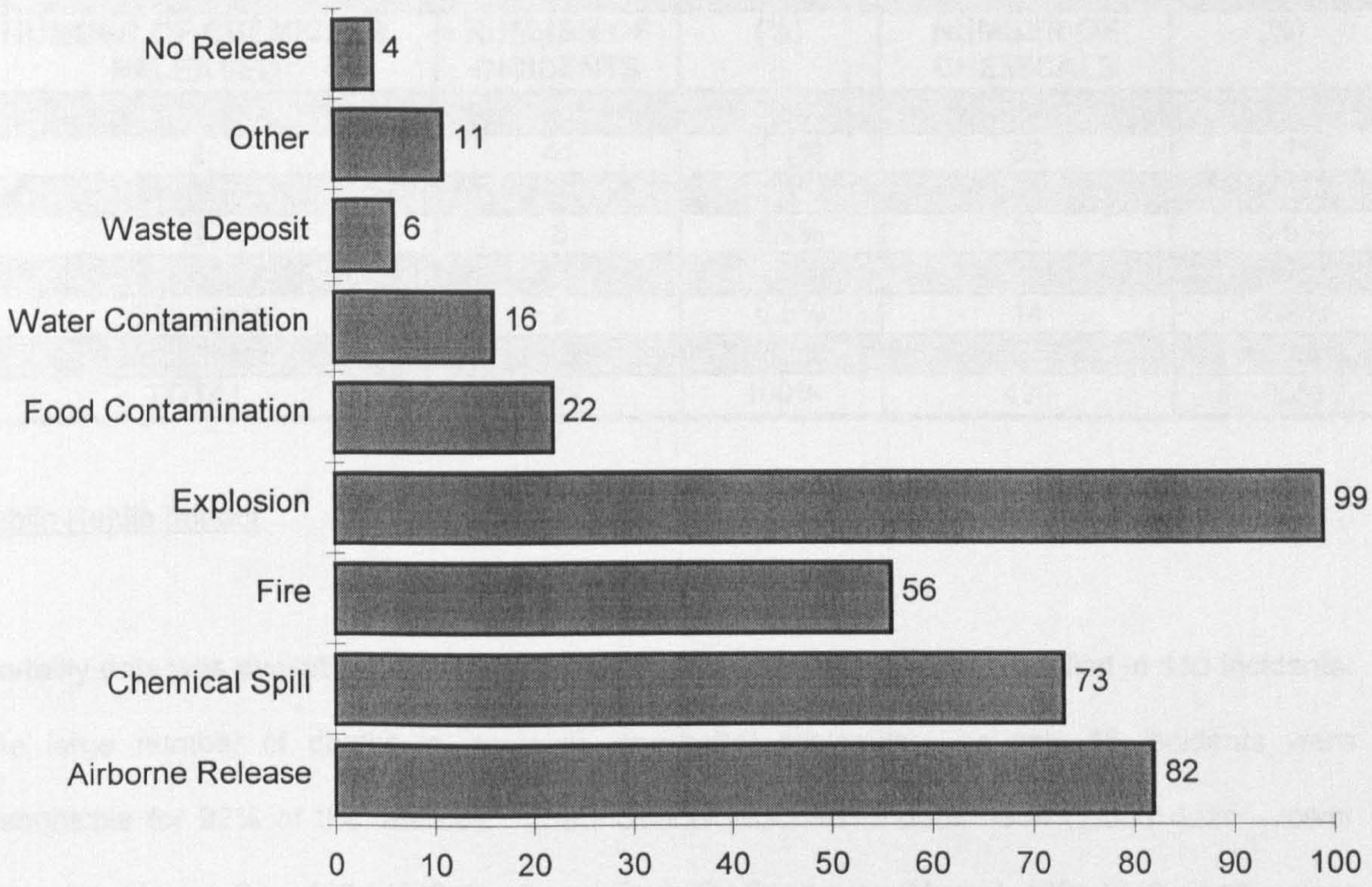


Figure 3.5 Distribution of 369 chemical incidents, by nature and location of incident

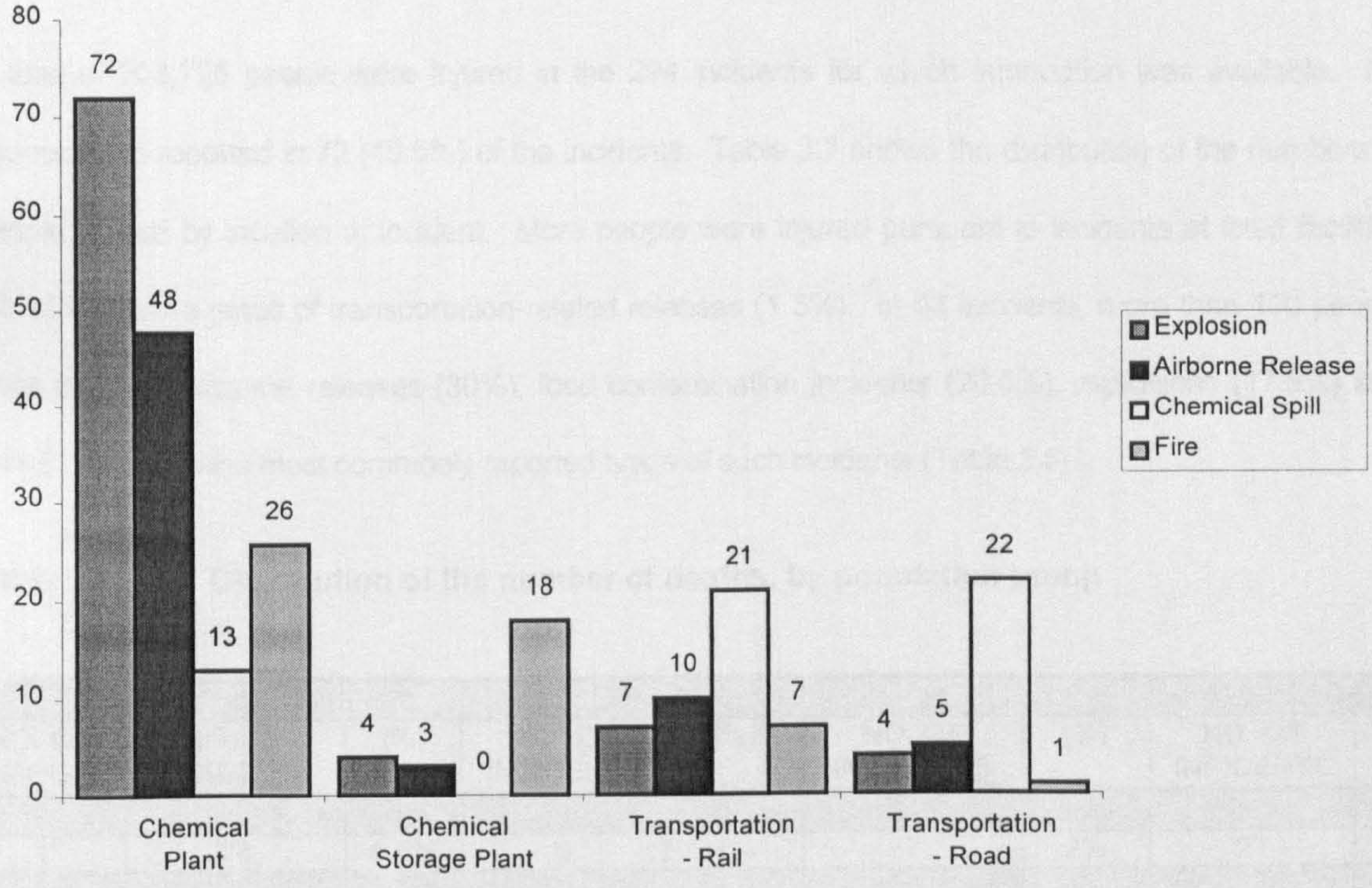


Table 3.5 Distribution of the number of chemicals released in all 369 incidents

NUMBER OF CHEMICALS RELEASED	INCIDENTS			
	NUMBER OF INCIDENTS	(%)	NUMBER OF CHEMICALS	(%)
1	286	77.5%	286	58.4%
2	41	11.1%	82	16.7%
3	17	4.6%	51	10.4%
4	8	2.2%	32	6.5%
5	5	1.4%	25	5.1%
6 or more	2	0.5%	14	2.9%
Not Stated	10	2.7%	0	0%
TOTAL	369	100%	490	100%

Public Health Impact

Mortality data was available for 361 of the incidents. A total of 14,175 people died in 110 incidents. The large number of deaths is, however, somewhat misleading, as only 16 incidents were responsible for 92% of the fatalities. The incidents included Bhopal, 1984 (2,500 dead - lower estimate), Mexico City, 1984 (542 dead) and Toxic Oil Syndrome, Madrid, 1981 (340 dead - lower estimate). Of those who died, 368 were employees, only 18 were responders and 13,789 were members of the public. Table 3.6 provides a breakdown of the numbers of deaths by population group.

A total of 203,725 people were injured in the 294 incidents for which information was available. No injuries were reported in 72 (19.5%) of the incidents. Table 3.7 shows the distribution of the numbers of people injured by location of incident. More people were injured pursuant to incidents at fixed facilities (85%) than as a result of transportation-related releases (1 5%). In 63 incidents, more than 100 people were injured. Airborne releases (30%), food contamination incidents (20.5%), explosions (17.5%) and fires (11%) were the most commonly reported types of such incidents (Table 3.8).

Table 3.6 Distribution of the number of deaths, by population group

	EMPLOYEES		RESPONDERS		PUBLIC		ALL INCIDENTS	
NO. OF DEATHS	NO. OF INCIDENTS	(%)	NO. OF INCIDENTS	(%)	NO. OF INCIDENTS	(%)	NO. OF INCIDENTS	(%)
0	299	81%	350	94.5%	313	85%	251	68%
1	20	5.5%	3	1%	7	2%	27	7.5%
2 - 4	20	5.5%	3	1%	3	1%	26	7%
5 - 9	8	2%	1	0%	9	2.5%	18	5%
10 - 49	8	2%	0	0%	8	2%	16	4%
50 - 99	2	0.5%	0	0%	1	0%	3	1%
100 >	0	0%	0	0%	16	4%	16	4%
TOTAL	369	100%	369	100%	369	100%	369	100%

Table 3.7 Distribution of the number of injured, by location of incident

NUMBER OF INJURED	FIXED FACILITY			TRANSPORTATION			ALL INCIDENTS		
	No. of Incidents	%	No. of Injured	No. of Incidents	%	No. of Injured	No. of Incidents	%	No. of Injured
0	29	11%	0	43	39%	0	72	19.5%	0
1	8	3%	8	7	6.5%	1	15	4%	15
2 - 4	13	5%	35	7	6.5	20	20	5.5%	55
5 - 9	26	10%	186	2	1.5%	12	28	8%	198
10 - 49	56	22%	1289	14	12.5%	289	70	19%	1578
50 - 99	22	8.5%	1522	4	3.5%	275	26	7%	1797
100 >	49	19%	169901	14	12.5%	30181	63	17%	200082
Not Stated	55	21.5%	0	20	18%	0	75	20%	0
TOTAL	258	100%	172941	111	100%	30788	369	100%	203725

Table 3.8 Classification of chemical incidents causing more than 100 injuries, by nature of incident (N = 63)

NATURE OF INCIDENT	ALL INCIDENTS		
	No. of Incidents	(%)	No. of Injured
Airborne Release	19	30%	121129
Chemical Spill	5	8%	1832
Fire	7	11%	4297
Explosion	11	17.5%	8414
Food Contamination	13	20.5%	41273
Water Contamination	3	5%	21094
Other	5	8%	2043
TOTAL	63	100%	200082

For fixed facility incidents, the population group most often injured were members of the public, followed by employees and responders, whereas for transportation-related incidents, more responders than employees were injured. The latter finding is not surprising given the likely attendance levels of responders, compared with employees. As has been cited elsewhere, it does however suggest that such individuals may need additional training and protective equipment (Agency for Toxic Substances and Disease Registry 1994; Hall *et al.* 1996).

Evacuations were ordered in 119 of the incidents. However, information on the numbers of people evacuated was only available for 68 (57%) of the incidents. The median number of people evacuated was 2,500, with a range of from 4 to 250,000. In 47 incidents, in-place sheltering was ordered.

Explosions

Ninety-nine (27% of the total) explosions were identified by the review (Table 3.9). In fifty-five, the explosions were followed by fires and in 7, by airborne releases. The remainder (N = 37) were reported purely as explosions. Chemical plants (N = 72) were the most frequently reported locations for explosions (Figure 3.6). Six explosions occurred during the transportation of chemicals by pipeline, accounting for 60% of all pipeline incidents. Information on the chemicals involved was available for all but 10 of the explosions. A single chemical was implicated in 68 of the incidents. Not surprisingly, liquefied gases figured highly in the chemicals listed.

The potential impact of explosions on human health is well illustrated by the fact that 59% of the incidents resulted in deaths, a figure far higher than for any other type of incident included within the review. Not surprisingly, the population group most affected were employees, with a cumulative total of 311 deaths reported in 42 incidents (no information was available for a further 4 incidents). In spite of the fact that only eleven incidents were recorded where members of the public were killed, the average number of deaths per incident was 213, with a range of 1 to 575. Seventeen responders were also killed in a total of 6 incidents.

A similar picture emerged in relation to the numbers of people injured. People were reported injured in 63 (80%) of the 79 incidents for which information was available. Again, the population group most affected were employees (41 incidents; 748 injured), followed by members of the public (16 incidents; 7974 injured) and responders (7 incidents; 73 injured).

Unfortunately, information on the necessity for population evacuation was lacking in relation to 38 of the incidents. Of those 61 explosions for which information was available, evacuation was advised in 35 (57%) cases. In-place sheltering was also recommended in 7 incidents.

Table 3.9 Line-listing of 99 explosions identified by the literature review

Year	Location	Country	Origin of Incident	Chemical	Deaths	Injuries	Evacuation	In-place sheltering	Reference
1970	Osaka	Japan	Chemical Plant	Liquefied Petroleum Gas	92	0	No	No	UNEP (1992)
1971	Texas	United States	Chemical Plant	Ethylene	4	60	Not Stated	Not Stated	UNEP (1992)
1973	Market Tree	United States	Transportation - Rail	Liquefied Petroleum Gas	0	0	Yes	No	UNEP (1992)
1974	Flixborough	United Kingdom	Chemical Plant	Cyclohexane	28	89	Yes	Not Stated	Kirkwood (1997)
1974	Decatur	United States	Transportation - Rail	Isobutane	7	152	No	No	UNEP (1992)
1976	Manfredonia	Italy	Chemical Plant	Arsenic	0	0	Yes	No	Haines (1994)
1976	Baton Rouge	United States	Chemical Plant	Chlorine	0	0	Yes	Not Stated	Pursnell (1976)
1978	Los Alfaques	Spain	Transportation - Road	Propylene	216	200	Not Stated	Not Stated	Arturson (1981)
1979	Bantry Bay	Republic of Ireland	Transportation - Sea	Crude oil	50	0	No	No	Garrison (1986)
1980	Mandir Asod	India	Chemical Plant	Explosives	50	0	No	No	UNEP (1992)
1980	Copenhagen	Denmark	Chemical Plant	Hexane	0	27	No	No	Gronberg et al. (1994)
1980	New Jersey	United States	Chemical Plant	Unlabelled chemical wastes	Not Stated	Not Stated	Not Stated	Not Stated	Costello et al. (1982)
1981	Tocaoa	Venezuela	Chemical Plant	Oil	145	1,000	No	No	UNEP (1992)
1981	New York	United States	Commercial	Polychlorinated dioxins	0	Not Stated	Yes	Not Stated	Schecter et al. (1985)
1981	Stalybridge	United Kingdom	Chemical Plant	Hexane	1	1	Yes	No	Health & Safety Executive (1982)
1982	Louisiana	United States	Chemical Storage Plant	Not Stated	0	0	Yes	No	Phillips (1992)
1982	Uithoorn	The Netherlands	Chemical Plant	Naphtha gas	3	Not Stated	No	Yes	Brinkmann (1994)
1982	Indiana	United States	Chemical Plant	Not Stated	0	0	Yes	No	Anon. (1986j)
1983	Grimsby	United Kingdom	Chemical Plant	Titanium tetrachloride	0	Not Stated	Not Stated	Not Stated	Anon. (1986a)
1983	Cheshire	United Kingdom	Transportation - Rail	Petroleum	0	Not Stated	Not Stated	Not Stated	Anon. (1983b)
1984	Pardubice	Czechoslovakia	Chemical Plant	Not Stated	4	50	Not Stated	Not Stated	Anon. (1984b)
1984	Mexico City	Mexico	Chemical Storage Plant	Liquefied Petroleum Gas	542	4,248	Yes	No	Anon. (1984a)
1984	Cubatao	Brazil	Transportation - Pipeline	Petroleum	508	3	Not Stated	No	TNO (1993)
1985	Barreiro	Portugal	Chemical Plant	Ammonia	0	8	Not Stated	Yes	Anon. (1985c)
1985	Iowa	United States	Chemical Plant	Ammonia	0	8	Not Stated	Not Stated	Anon. (1985l)
1986	Derbyshire	United Kingdom	Waste Disposal Site	Methane	0	3	Yes	No	Fricker (1986)
1986	Ohio	United States	Chemical Plant	Ammonium dichromate	2	12	Not Stated	Not Stated	Anon. (1986h)
1986	Durham	United Kingdom	Chemical Plant	Disulphate	1	2	Yes	No	Malpass (1986)
1986	Merseyside	United Kingdom	Chemical Plant	Di-n-pentyl ether	0	Not Stated	Yes	No	Whitehouse (1987)
1986	Sydney	Australia	Chemical Plant	Phthalic anhydride	5	14	Not Stated	Not Stated	Loader (1987)
1987	Lyons	France	Chemical Plant	Hydrocarbons	2	14	Yes	Not Stated	Brette et al. (1993)
1987	Grangemouth	United Kingdom	Chemical Plant	Hydrocarbons	1	Not Stated	No	Yes	Smith and Purdy (1990)
1987	Texas	United States	Chemical Plant	Acetic acid	3	35	Not Stated	Not Stated	Reisch (1987)
1988	Nevada	United States	Chemical Plant	Ammonium perchlorate	0	Not Stated	Not Stated	Not Stated	Segraves et al. (1991)
1988	California	United States	Chemical Plant	Hydrogen peroxide	2	6	Not Stated	Not Stated	Anon. (1988h)
1988	Gwynedd	United Kingdom	Chemical Plant	Explosives	2	9	Not Stated	Not Stated	Anon. (1988e)
1988	Kansas City	United States	Other	Ammonium nitrate	6	Not Stated	Not Stated	Not Stated	Anon. (1989f)
1988	Sines	Portugal	Chemical Plant	Petroleum	2	1	No	No	Ventura et al. (1995)
1988	Auzouer en Touraine	France	Chemical Plant	Not Stated	0	0	Not Stated	Not Stated	Brette et al. (1993)
1988	Mulhouse	France	Chemical Plant	Not Stated	0	0	Not Stated	Not Stated	Brette et al. (1993)
1988	Texas	United States	Transportation - Rail	Liquefied Petroleum Gas	0	0	Yes	No	Anon. (1988c)
1989	Peterborough	United Kingdom	Transportation - Road	Not Stated	0	82	Not Stated	Not Stated	Evans et al. (1990)
1989	Texas	United States	Chemical Plant	Petrochemicals	23	133	Not Stated	Not Stated	Anon. (1989l)
1989	Botlek	The Netherlands	Chemical Storage Plant	Acrylonitrile	3	2	Yes	No	Wiersman et al. (1994)
1989	Rosteig	France	Transportation - Pipeline	Naphtha	3	0	Yes	Not Stated	Brette et al. (1993)

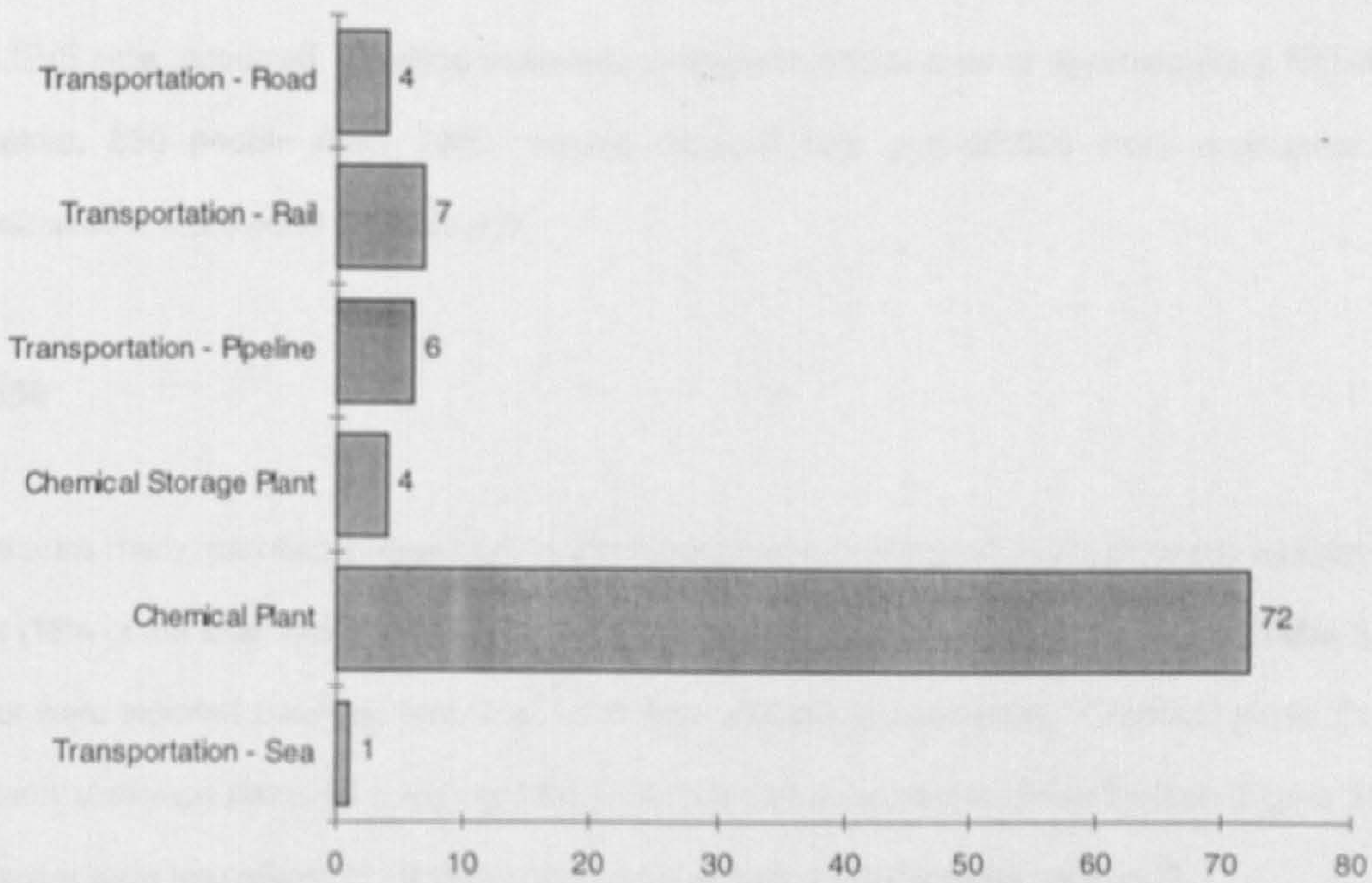
Year	Location	Country	Origin of Incident	Chemical	Deaths	Injuries	Evacuation	In-place sheltering	Reference
1989	Montana	United States	Transportation - Rail	Hydrogen peroxide	0	1	Yes	No	Anon. (1989c)
1989	Ohio	United States	Transportation - Rail	Butane	0	0	Yes	Not Stated	Anon. (1989d)
1989	Rouen	France	Chemical Plant	Ammonia	2	Not Stated	Not Stated	Not Stated	Anon. (1989e)
1989	Attica	Greece	Chemical Plant	Petroleum	0	8	No	No	Ziomas et al. (1994)
1989	Ufa	Soviet Union	Transportation - Pipeline	Liquefied Peteroleum Gas	575	623	Not Stated	Not Stated	Anon. (1989b)
1990	Viana do Castelo	Portugal	Transportation - Pipeline	Oxygen	0	0	Yes	No	Ventura et al. (1995)
1990	Cheshire	United Kingdom	Chemical Plant	Difluoroaniline	1	5	No	No	Cates (1992)
1990	Tokyo	Japan	Chemical Plant	Benzol peroxide	9	17	Not Stated	Not Stated	Anon. (1991g)
1990	Texas	United States	Chemical Plant	Methyl tert-butyl ether (MTBE)	17	5	Not Stated	Not Stated	Anon. (1990c)
1990	Lisbon	Portugal	Transportation – Road	Batteries	1	3	Not Stated	Not Stated	Ventura et al. (1995)
1990	Barquerios	Portugal	Transportation – Road	Petroleum	1	2	Yes	Not Stated	Ventura et al. (1995)
1990	Tarragona	Spain	Chemical Plant	Propylene	0	0	Not Stated	Not Stated	Vilchez Sanchez et al. (1995)
1991	Derby	United Kingdom	Chemical Plant	Acetone	0	10	No	No	Anon. (1991c)
1991	Liaoning	China	Chemical Plant	Trinitrotoluene (TNT)	17	107	No	No	Haines (1994)
1991	Rotterdam Port	The Netherlands	Chemical Plant	Benzoic acid	7	3	Yes	No	Anon. (1992b)
1991	Louisiana	United States	Chemical Plant	Nitroparaffin	8	125	Yes	Not Stated	Thayer (1991)
1991	Texas	United States	Chemical Plant	Ethylene oxide	1	Not Stated	Not Stated	Not Stated	Viera et al. (1993)
1991	Texas	United States	Chemical Plant	Ethylene oxide	1	19	Yes	No	Viera et al. (1993)
1991	Bangkok	Thailand	Chemical Storage Plant	Not Stated	5	Not Stated	Yes	No	Anon. (1991e)
1992	Texas	United States	Transportation - Pipeline	Liquefied Natural Gas	0	3	Yes	Not Stated	Anon. (1992h)
1992	Texas	United States	Chemical Plant	Not Stated	0	40	Yes	No	Anon. (1992f)
1992	Kansas City	United States	Chemical Plant	Ethyl alcohol	3	Not Stated	Not Stated	Not Stated	Anon. (1992c)
1992	Guadalajara	Mexico	Transportation - Pipeline	Petroleum	250	1,470	Yes	No	Haines (1994)
1992	Castleford	United Kingdom	Chemical Plant	Nitrotoluene	5	156	No	No	Anon. (1992d)
1992	Tenerife	Spain	Chemical Plant	Petroleum	1	4	No	No	Vilchex Sanchez et al (1995)
1992	Not Stated	The Netherlands	Chemical Plant	Dicyclopentadiene	3	8	Yes	Yes	Wiersman et al (1994)
1992	Piraeus	Greece	Chemical Plant	Dimethoate	0	Not Stated	No	No	Ziomas et al. (1994)
1992	Tarragona	Spain	Chemical Plant	Ethylene	0	12	No	Yes	Vilchex Sanchez et al (1995)
1992	Uithoorn	The Netherlands	Chemical Plant	Boron trifluoride	3	11	No	No	Wiersman et al. (1992)
1992	Marseilles	France	Chemical Plant	Butane	6	Not Stated	No	No	Brette et al. (1992)
1992	Milford Haven	United Kingdom	Chemical Plant	Hydrocarbons	0	18	Not Stated	Not Stated	Smith and Purdy (1990)
1993	Tel Aviv	Israel	Chemical Plant	Hydrochloric acid	1	40	Not Stated	Not Stated	Anon. (1993h)
1993	Sumitomo	Japan	Chemical Plant	Epoxy resin	Not Stated	Not Stated	Not Stated	Not Stated	Anon. (1993d)
1993	Urals	Soviet Union	Chemical Plant	Nitrobenzene	4	3	No	No	TNO (1993)
1993	Shenzhen	China	Chemical Plant	Nitric acid	70	200	No	No	TNO (1993)
1993	Ohio	United States	Chemical Plant	Hydrochloric acid	0	Not Stated	Yes	Not Stated	Thayer (1993)
1993	Frankfurt	Germany	Chemical Plant	Methanol	1	1	No	Yes	Anon. (1993g)
1993	Neratovice	Czechoslovakia	Chemical Plant	Vinyl chloride monomer	0	12	Not Stated	Not Stated	Anon. (1993b)
1994	Milford Haven	United Kingdom	Chemical Plant	Hydrocarbons	0	26	Yes	No	Anon. (1994g)
1994	Pennsylvania	United States	Chemical Plant	Styrene	0	39	Yes	No	Anon. (1994l)
1994	Ohio	United States	Chemical Plant	Butadiene	3	Not Stated	Not Stated	Not Stated	Anon. (1994f)
1995	Rio Tercero	Argentina	Chemical Plant	Munitions	13	Not Stated	Yes	No	Anon. (1996j)
1995	New Jersey	United States	Chemical Plant	Sulphur dioxide	4	8	Yes	Not Stated	Anon. (1995c)
1995	Rheims	France	Other	Polychlorinated biphenyl	0	0	Yes	No	Anon. (1995e)
1995	Ladwigshafen	Germany	Chemical Plant	Sulphuric acid	1	3	Not Stated	Not Stated	Anon. (1995d)
1996	Mannheim	Germany	Chemical Plant	Zinc	0	13	Not Stated	Not Stated	Anon. (1996b)
1996	Huddersfield	United Kingdom	Chemical Plant	Sulphuric acid	0	Not Stated	No	Not Stated	Anon. (1997h)
1996	Avonmouth	United Kingdom	Chemical Plant	Epichlorohydrin	0	11	No	Yes	Department of Health (1996)
1996	Schonebeck	Germany	Transportation - Rail	Vinyl chloride monomer	0	40	No	No	Anon. (1996e)
1996	Massachusetts	United States	Other	Hydrogen	0	17	Yes	No	Anon. (1996d)
1997	Beijing	China	Chemical Plant	Not Stated	3	64	Not Stated	Not Stated	Anon. (1997c)

Year	Location	Country	Origin of Incident	Chemical	Deaths	Injuries	Evacuation	In-place sheltering	Reference
1997	Chongqing	China	Chemical Plant	Not Stated	12	6	Not Stated	Not Stated	Anon. (1997e)
1997	Arkansas	United States	Chemical Plant	Azinphos-methyl	3	12	Not Stated	Not Stated	Anon. (1997)
1997	Milton Keynes	United Kingdom	Chemical Plant	Chlorinated paraffin	1	11	No	No	Personal Communication (1997)

Special Features of Explosions

Explosions are characterised by a shock-wave. Heard as a bang, explosions cause damage to buildings, break windows and can eject objects over distances of several hundreds of metres. Injuries and damage are initially caused by the shock-wave of the explosion, the effects of which will be dependent on the characteristics and quantities of the chemical(s) involved and the degree of confinement of the vapour cloud. Loss of life generally occurs at pressures above 10 kilopascals (kPa). Putting this into context, the explosion of a tank containing 50 tonnes of propane would result in a pressure of 14kPa at 250 metres (International Labour Organisation 1988).

Figure 3.6 Distribution of 99 explosions, by location of incident



Boiling-Liquid Expanding-Vapour Explosions (BLEVEs)

As stated earlier, it is often difficult to make a distinction between an explosion and a fire (International Labour Organisation 1988). A BLEVE is a combination of explosion and fire. The phenomenon occurs when a vessel, within which a liquefied gas is kept above its atmospheric boiling point, fails as a result of it being punctured or its structure weakened by, for example, a fire impinging on its surface. The contents, which are instantaneously released, mix with air to form an explosive vapour cloud. On ignition, a "fire-ball" is quickly formed. Besides the direct burns caused within the immediate vicinity of the "fire-ball", the radiant heat is sufficient to cause severe skin burns and deaths up to 300 metres from the flames (Arturson 1981). The vessel involved in the BLEVE also becomes a dangerous projectile. At San Juanico (see below), a 45 m^3 tank flew 1200 metres (Arturson 1981).

The effects of BLEVEs are unfortunately all too well known. In 1974, ignition of a cloud of cyclohexane over a petrochemical works at Flixborough in the United Kingdom started a fire in which 28 people were killed and 89 were injured (Department of Employment 1975; Kirkwood 1997). On 11 July 1978, a road tanker carrying liquefied propene ran into a ditch outside the Los Alfaques camp site on the east coast of Spain. The tank split and the resulting BLEVE killed 102 instantaneously, and a further 119 of 140 who were removed from the scene suffering from severe burns (Arturson 1981). The worst disaster of its kind, however, occurred on 19 November 1984 at a large liquefied petroleum gas storage and distribution depot in San Juan Ixhuatepec, 20 km north of Mexico City (Arturson 1987). Following a fire at the depot, thirteen explosions, some of the BLEVE type, occurred, resulting in severe damage to a total area of approximately 100,000 square metres. 550 people died, 7000 needed medical help and 60,000 were evacuated. Further examples are provided in Table 3.9.

Fires

Because many manufacturing processes involve petroleum products, fires are common occurrences. Fifty-six (15% of the total) incidents of fires involving chemicals were identified by the review (Table 3.10). Forty-four were reported purely as fires, and 12 as fires followed by explosions. Chemical plants (N = 26) and chemical storage plants (N = 18) were the most commonly reported locations for fires (Figure 3.7). A small number were also related to the transportation of hazardous chemicals by rail (N = 7).

Special Features of Chemical Fires

The problems faced by public health professionals when assessing the potential health effects arising from fires include: (a) identification and quantification of the combustion products of potentially large numbers of different chemicals; (b) evaluation of the likely dispersion patterns of combustion products; (c) identification of toxic substances in fire-fighting waters; and, (d) the likely effects of fire-fighting water migration on the operation of sewage treatment plants, potable water supplies and recreational waters.

Smoke Toxins

For 51 of the fires identified through the review, information was available on the source chemicals involved. Interestingly, a single chemical was implicated in only 25 (49%) of the fires, which compares with a percentage figure of 78% for all incidents. This is not a surprising finding, when one considers that many fires arise due to the incompatible storage of 2 or more chemicals. For example, the fire at Alloid Colloids, Bradford (July 1992), was caused by the incorrect storage of drums of a flammable solid (azodiisobutyronitrile) and an oxidising agent (persulphates) (Anon 1992a).

As stated above, however, it is not just the original chemicals involved in a fire with which public health professionals should be concerned, but also the health effects that may arise from exposure to the so-called "smoke toxins" generated as a result of the fire, for example, nitrous oxides from fires involving ammonium nitrate (International Labour Office 1988). Unfortunately, the combinations and reactions of the different chemicals and substances that may be involved in a fire are poorly understood (Christiansen, Kakko and Koivisto 1993; Atkinson and Jagger 1994). Such information is also difficult to obtain, as numerous compounds can be produced, and the means for collecting air samples is often not readily available (Baxter, Heap, Rowland and Murray 1995). For polyvinyl chloride, research has shown that some 75 different combustion products may be evolved (Markowitz *et al.* 1989). Decision-making based on a hazards and risk assessment approach is therefore likely to be hampered, in the case of fires.

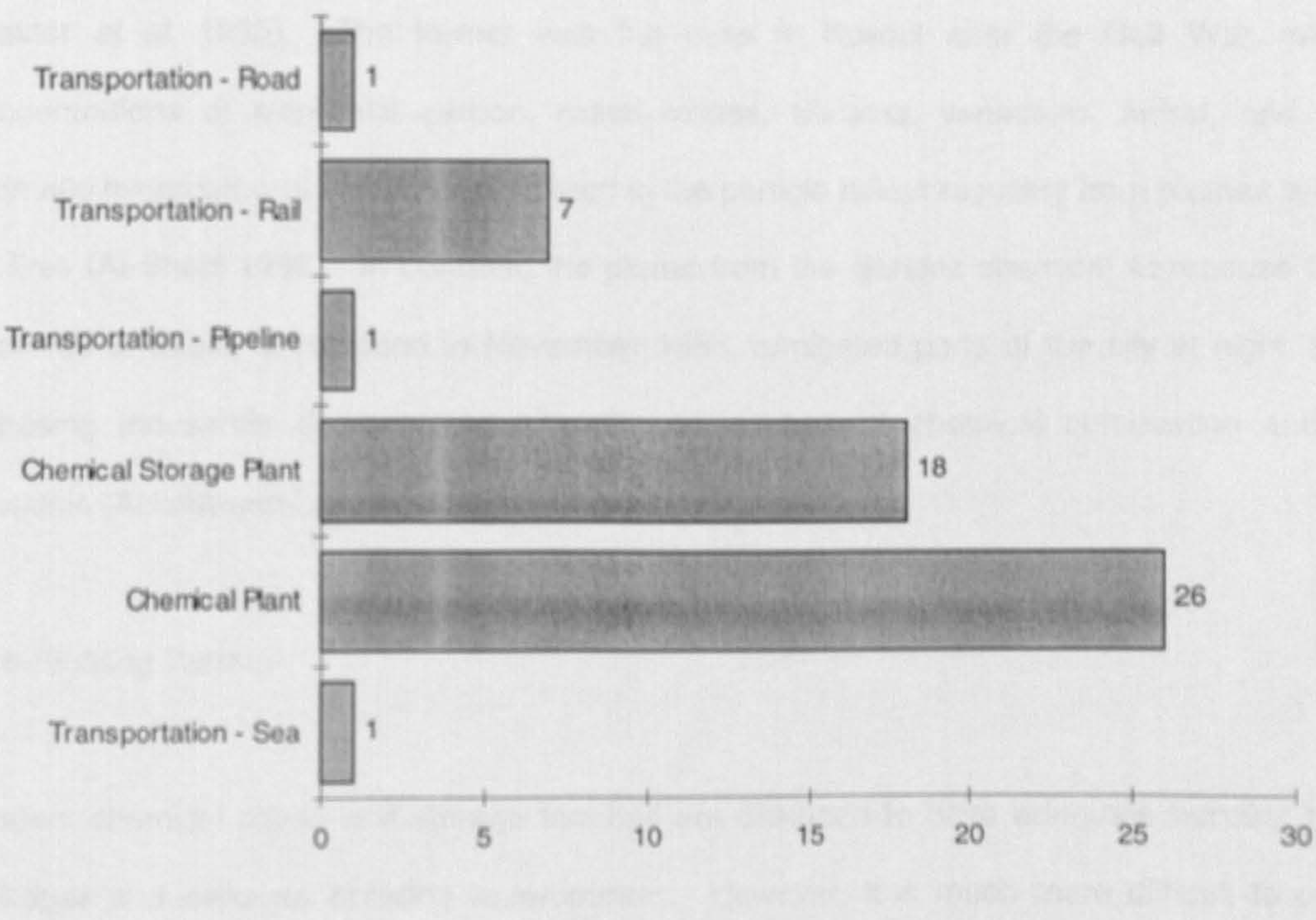
Table 3.10 Line-listing of 56 chemical fires identified by the literature review

Year	Location	Country	Origin of Incident	Chemicals	Deaths	Injuries	Evacuated	Reference
1947	Texas	United States	Transportation - Sea	Ammonium nitrate	576	2000	Not Stated	Quarentelli (1991)
1975	Beek	The Netherlands	Chemical Plant	Ethylene	14	107	No	UNEP (1992)
1980	Barking	United Kingdom	Chemical Storage Plant	Sodium cyanide	0	12	Yes	Smith and Purdy (1990)
1982	Salford	United Kingdom	Chemical Storage Plant	Sodium chlorate	0	160	Yes	Anon. (1982i)
1983	Milford Haven	United Kingdom	Chemical Plant	Crude oil	0	6	No	Campbell (1994)
1984	Sheffield	United Kingdom	Chemical Storage Plant	Not Stated	0	22	No	Smith and Purdy (1990)
1984	Sheffield	United Kingdom	Chemical Storage Plant	Polyurethane foam (cyanides, isocyanates, carbon monoxide), polyvinyl chloride (hydrochloric acid), sulphur dioxide, nitrous fumes	0	Not Stated	Not Stated	Smith and Purdy (1990)
1984	Auckland	New Zealand	Chemical Storage Plant	Pesticides	0	235	Yes	Temple (1993)
1984	Auckland	New Zealand	Chemical Plant	Not Stated	0	30	Not Stated	Temple (1993)
1985	California	United States	Chemical Storage Plant	Pesticides	0	9	Yes	Bhopal Working Group (1987)
1985	New Jersey	United States	Chemical Plant	Polyvinyl chloride	0	80	Not Stated	Markowitz et al. (1985)
1986	Thessaloniki	Greece	Chemical Plant	Crude oil	0	25	No	Ziomas et al. (1994)
1986	Basel	Switzerland	Chemical Storage Plant	Phosphorus-based insecticides	0	1,363	No	Ackerman-Liebrich (1992)
1986	Ohio	United States	Transportation - Rail	White phosphorus	0	140	Yes	Anon. (1986b)
1986	Billingham	United Kingdom	Chemical Plant	Nitric oxide	1	15	No	Smith and Purdy (1990)
1986	Derbyshire	United Kingdom	Chemical Plant	Not Stated	0	0	Not Stated	Coates et al. (1987)
1987	Port Rashid	Dubai	Chemical Plant	Malathion	0	Not Stated	Not Stated	Anon. (1987c)
1987	Lisbon	Portugal	Transportation - Pipeline	Butane	0	0	Yes	Ventura et al. (1995)
1987	Nantes	France	Chemical Storage Plant	Fertiliser	0	5	Yes	Brette et al. (1993)
1987	Dax	France	Transportation - Rail	Petroleum	0	0	Yes	Brette et al. (1993)
1988	Arhuus	Denmark	Chemical Storage Plant	Soap	0	0	0	Gronberg et al. (1994)
1988	Poole	United Kingdom	Chemical Storage Plant	Methylated spirit, chlorinated solvents	0	21	Yes	Thwaites (1988)
1988	Hyogo Prefecture	Japan	Chemical Storage Plant	Chlorosilane	0	1	Yes	Anon. (1989a)
1988	Quebec	Canada	Chemical Storage Plant	Polychlorinated biphenyls	0	Not Stated	Yes	Aubin et al (1994)
1989	Illinois	United States	Chemical Plant	Acetylene	1	17	Not Stated	Anon. (1989l)
1989	Noord-Brabant	The Netherlands	Transportation - Rail	Methanol	0	0	Yes	Wiersman et al. (1994)
1989	Ghent	Belgium	Chemical Plant	Polystyrene	0	1	Yes	Behaegel et al. (1995)
1989	Holeby	Denmark	Chemical Plant	Pesticides	0	2	No	Gronberg et al. (1994)
1989	Attica	Greece	Chemical Plant	Petroleum	0	0	No	Ziomas et al. (1994)
1989	Michigan	United States	Transportation - Rail	Acrylic acid	0	Not Stated	Yes	Anon. (1989g)
1990	Carrington	United Kingdom	Chemical Plant	Polypropylene	Not Stated	Not Stated	Not Stated	Anon. (1990d)
1990	Washington	United States	Chemical Plant	Trichloroethylene	0	27	Yes	Jones (1993)
1990	Leca da Palmeira	Portugal	Chemical Plant	Propane	2	8	No	Ventura et al. (1995)
1990	Chavanay	France	Transportation - Rail	Petroleum	0	Not Stated	Yes	Brette et al. (1993)
1991	Melbourne	Australia	Chemical Plant	Acrylonitrile	Not Stated	Not Stated	Not Stated	Anon. (1991b)
1991	Herent	Belgium	Chemical Plant	Perchloroethylene	0	9	Yes	Behaegel et al. (1995)
1991	Deurne	Belgium	Chemical Plant	Pesticides	0	13	No	Behaegel et al. (1995)
1991	Somerset	United Kingdom	Transportation - Rail	Diesel	0	0	Yes	Anon. (1991a)
1991	Leicester	United Kingdom	Waste Disposal Site	Asbestos	0	0	No	Smith and Purdy (1990)
1991	Thetford	United Kingdom	Waste Disposal Site	Polyvinyl chloride	0	53	0	Baxter et al. (1991)
1991	Cordoba	Mexico	Chemical Plant	Pentachlorophenol	0	292	Yes	Albert (1993)
1991	Victoria	Australia	Chemical Storage Plant	Benzene	Not Stated	Not Stated	Not Stated	Anon. (1991h)
1991	Auckland	New Zealand	Chemical Storage Plant	Not Stated	0	30	Yes	Kirk (1992)
1991	Saskatchewan	Canada	Transportation-Rail	Sodium	0	0	Yes	Rosato (1992)
1992	Bradford	United Kingdom	Chemical Plant	Azodiisobutyronitrile	0	83	Yes	Anon. (1992a)

Year	Location	Country	Origin of Incident	Chemicals	Deaths	Injuries	Evacuated	Reference
1992	North Carolina	United States	Chemical Storage Plant	Pesticides	0	20	No	Jones (1993)
1993	Shropshire	United Kingdom	Chemical Storage Plant	Organophosphate Pesticides	0	Yes	No	Anon. (1993c)
1993	Vilvorde	Belgium	Chemical Plant	Xylene	0	6	Yes	Behaegel et al. (1995)
1994	Haifa	Israel	Chemical Plant	Potassium fertiliser	0	9	Not Stated	Anon. (1994e)
1994	Michigan	United States	Transportation - Rail	Sodium isopropylxanthate	0	0	Yes	Anon. (1994b)
1994	Poole	United Kingdom	Chemical Plant	Not Stated	0	7	Yes	Anon. (1994f)
1995	Wilton	United Kingdom	Chemical Storage Plant	Polypropylene	0	0	No	Lindley et al. (1996)
1996	Middlesbrough	United Kingdom	Transportation - Road	Nitrobenzene	0	12	No	Anon. (1996a)
1996	Dudley	United Kingdom	Chemical Plant	Dichloromethane	0	7	No	Harrison and Vale (1996)
1997	Khabarovsk	Soviet Union	Chemical Plant	Chlorine	1	63	Not Stated	Anon. (1997f)

The lack of available information on products of combustion accounts for the fact that most fire casualties are attributable to the effects of toxic gases, as opposed to burns (Bowes 1976; Terrill, Montgomery and Reinhardt 1978; Markowitz *et al.* 1989), with severity inversely proportional to the square of the distance from the source (International Labour Office 1988; Lillibridge 1997). Fortuitously, only 7 of the incidents resulted in deaths, mainly of limited numbers of employees. The exception was the fire and explosion which occurred in 1947 in Texas City, where fire broke out on a ship carrying ammonium nitrate fertiliser, resulting in an explosion which instantaneously killed 576 members of the general public (Quarentelli 1991; Robertson 1995).

Figure 3.7 Distribution of 56 chemical fires, by location of incident



Casualties were however reported in 37 of the 48 incidents for which information was available. Members of the public were injured in 17 incidents, and employees in 9 incidents. The population group most frequently injured, however, were emergency responders. A cumulative total of 553 fire-fighters and 22 police officers were injured in 18 incidents, highlighting the risks faced by such workers. A good example is provided by a major fire, which occurred at a site used for the storage of ground scrap plastic, at Thetford, United Kingdom in 1991 (Baxter *et al.* 1995). Forty-six of the 53 casualties were emergency personnel who had inadvertently received exposure to the fire smoke. Although the symptoms resolved within 48 hours, concerns were also expressed over the potential long term health effects.

Plume Dispersion

The rates and mechanisms of dispersion of the products of combustion are also critical to the prediction of health impact, and in guiding evacuation policy. In this latter respect, population evacuation was advised in a high percentage - 57% - of the 44 fires for which information was available. In 13 incidents, in-place sheltering was also recommended.

It is important to recognise that plumes may be convected away from population areas by the intense heat of a fire, but nevertheless still pose a health hazard from particle fallout. Alternatively, they may expand by diffusion or be driven to ground level by cooling, wind, or thermal inversions (Baxter *et al.* 1995). The former was the case in Kuwait after the Gulf War, where high concentrations of elemental carbon, metal oxides, silicates, vanadium, nickel, and polycyclic aromatic hydrocarbons were all determined in the particle fallout resulting from plumes arising from oil fires (Al-Shatti 1992). In contrast, the plume from the Sandoz chemical warehouse fire, which occurred at Basel, Switzerland in November 1986, fumigated parts of the city at night, potentially exposing thousands of people to an unknown mixture of chemical combustion and reaction products (Ackermann-Liebrich 1992).

Fire-Fighting Waters

Modern chemical plants and storage facilities are designed to have adequate bunding to prevent spillages and leakages entering watercourses. However, it is much more difficult to protect the environment from the consequences of fire incidents (Meharg *et al.* 1997). This is because the quantities of water used in fire-fighting overwhelm most spillage containment systems (if present). For example, some four million gallons of water were used for extinguishing and cooling in relation to the fire at Alloid Colloids, Bradford in July 1992 (Amess 1994). The result was a significant quantity of polluting material being released off-site into the local river system. The issues for public health professionals, in such circumstances, relate primarily to the potential pollution impact sites downstream of the release, for example, fish farms and shellfish beds, potable water abstractions points and recreational waters.

In response to this and similar experiences at other incidents, guidance was issued by the UK Health and Safety Executive in 1995 setting out measures to be taken by industry to prevent pollution of watercourses by contaminated fire-fighting waters (Health and Safety Executive 1995). The guidance also suggested that there may be cases where it would be more appropriate to allow chemical fires to burn out under control in order to avert a major water pollution incident. Such circumstances were to be considered as part of contingency planning.

<u>Airborne Releases</u>

There are large numbers of chemicals which, if released, have the potential to disperse with the wind and kill or injure people living many hundreds of metres away from the original site of an incident. Table 3.11 provides details of the 82 incidents of airborne releases (22% of the total) which were identified by the review. All but four were reported purely as airborne releases. The most frequently reported locations of such incidents were chemical plants (N = 48) (Figure 3.8). Only seventeen incidents were transportation-related, 10 involving transport by rail, 4 occurring on the highway and 3 happening at sea. The category "other" includes acts of chemical terrorism (N = 2) and natural disasters (N = 3), both of which are covered in subsequent sections of the literature review.

Information on the chemicals involved was available for all 82 incidents. Seventy-two resulted in the release of a single chemical. Those most frequently expelled were chlorine (N = 17) and ammonia (N = 8), which is not surprising given the fact that both have been produced and used in large quantities since the beginning of the century (Advisory Committee on Major Hazards 1979).

The immediate effects of population exposures to toxic releases of chemicals may be burns injuries, acute chemical toxicity, acute respiratory and conjunctival irritation, or the sight and smell of smoke and fumes inducing fear in populations (Mayon-White 1997). Provided the acute episode is survived without neurological sequelae, complete recovery usually occurs. However, exposure to irritant gases may occasionally result in the longer term respiratory illnesses bronchiolitis, reactive airways dysfunction syndrome and pulmonary fibrosis (Watt, Watt and Seaton, 1997).

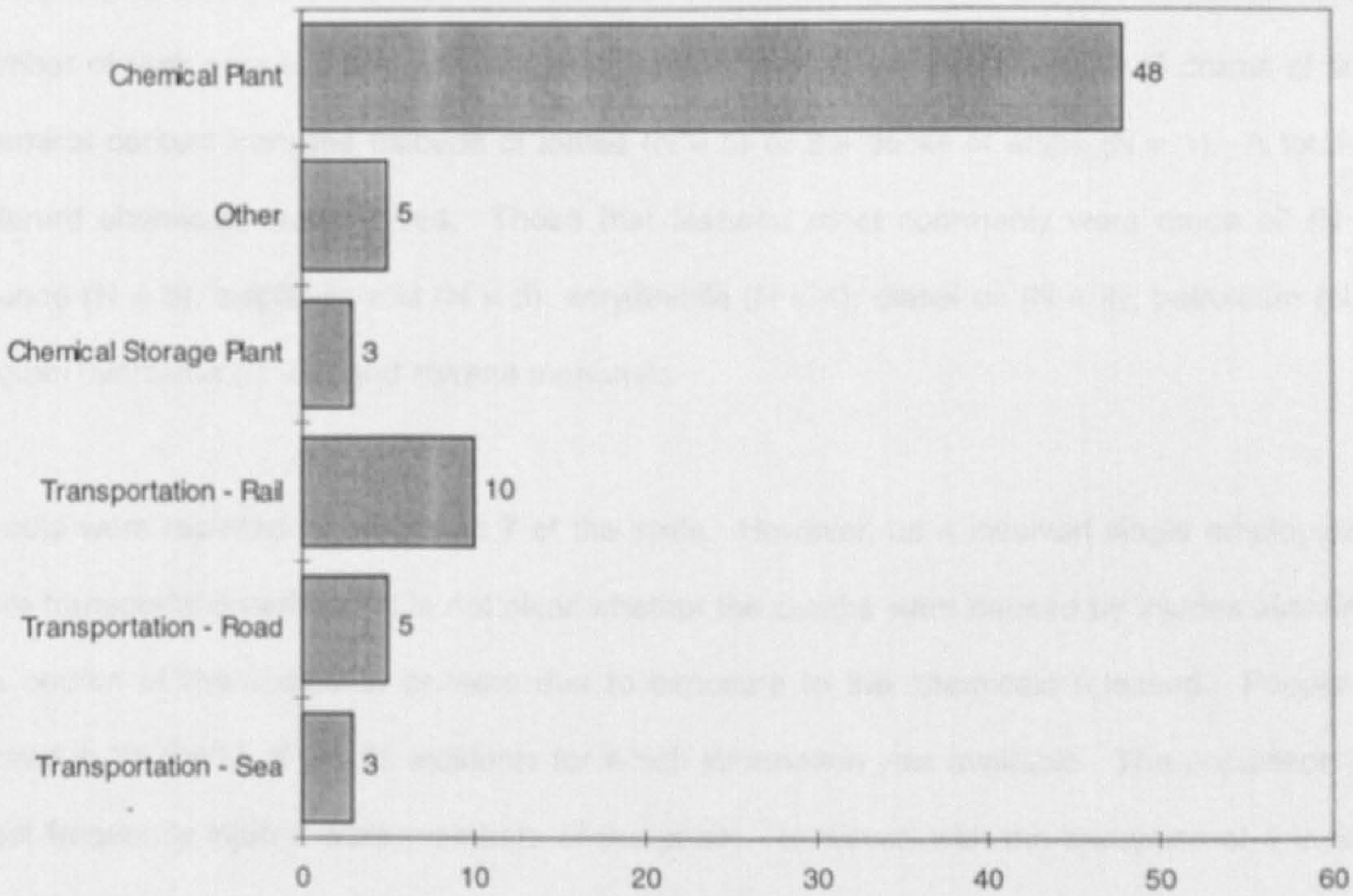
Table 3.11 Line-listing of 82 airborne releases identified by the literature review

Year	Location	Country	Origin of Incident	Chemical	Deaths	Injuries	Evacuated	Reference
1952	London	United Kingdom	Other	Sulphur dioxide	3,500 - 4,000	Not Stated	No	WHO (1991)
1973	Fort Wayne	United States	Transportation - Rail	Vinyl Chloride	0	0	Yes	UNEP (1992)
1973	Potchefstroom	South Africa	Chemical Plant	Ammonia	18	Not Stated	Not Stated	McQuaid (1988)
1973	Greensburg	United States	Transportation - Rail	Chlorine	0	0	Yes	UNEP (1992)
1975	Heimstetten	Germany	Chemical Storage Plant	Nitrogen oxide	0	0	Yes	UNEP (1992)
1976	Seveso	Italy	Chemical Plant	Dioxin	0	193	Yes	Marshall (1992)
1976	Texas	United States	Transportation - Road	Ammonia	6	178	No	McQuaid (1988)
1979	Mississauga	Canada	Transportation - Rail	Chlorine	0	0	Yes	McQuaid (1988)
1981	New Jersey	United States	Transportation - Rail	Ethylene oxide	0	Not Stated	Yes	Anon. (1981b)
1982	Altona	Australia	Chemical Plant	Vinyl chloride monomer	Not Stated	Not Stated	Not Stated	Kilmartin (1985)
1983	Knoxville	United States	Chemical Plant	Chlorine	0	0	Yes	Anon. (1985b)
1984	Louisiana	United States	Chemical Plant	Anhydrous Ammonia	1	1	Not Stated	Klem (1986)
1984	Baltic Sea	Baltic Sea	Transportation - Sea	Mustard gas	0	7	No	Gronberg et al. (1994)
1984	Barcelona	Spain	Transportation - Sea	Soya Bean Dust	1	64	No	Anto et al. (1986)
1984	Lake Monoun	Cameroon	Natural Disaster	Carbon dioxide	37	Not Stated	Not Stated	Wagner et al. (1986)
1984	New Jersey	United States	Chemical Plant	Malathion	0	161	No	Markowitz et al. (1994)
1984	Bhopal	India	Chemical Plant	Methyl isocyanate	2,500	80,000	Yes	Bhopal Working Group (1987)
1984	Cleveland	United Kingdom	Transportation - Road	Epichlorohydrin	0	Not Stated	Yes	Smith and Purdy (1990)
1984	Geneva	Switzerland	Chemical Plant	Bromine	0	91	Yes	Morabia et al. (1988)
1985	West Virginia	United States	Chemical Plant	Mesityl oxide	0	8	Not Stated	Anon. (1985a)
1985	West Virginia	United States	Chemical Plant	Dichloromethane	0	134	No	Mackensie (1985)
1985	Karlskoga	Sweden	Chemical Plant	Oleum (sulphuric acid)	Not Stated	Not Stated	Not Stated	Anon. (1985h)
1985	New Delhi	India	Chemical Plant	Sulphur trioxide	0	250	Not Stated	Anon. (1985g)
1985	Pennsylvania	United States	Chemical Plant	Pentaerythritol tetracrylat	0	Not Stated	Not Stated	Anon. (1985d)
1985	Bombay	India	Chemical Plant	Chlorine	1	153	No	TNO (1993)
1985	Bristol	United Kingdom	Commercial	Chlorine	0	48	Yes	Philip et al. (1985)
1985	Yorkshire	United Kingdom	Chemical Plant	Chlorine	0	14	Yes	Anon. (1985b)
1985	New Jersey	United States	Chemical Plant	Hydrogen sulphide	0	Not Stated	Not Stated	Anon. (1985f)
1985	Lyons	France	Transportation - Road	Butane	0	0	Yes	Brette et al. (1993)
1985	Bhopal	India	Chemical Plant	Chlorine	0	7	Not Stated	Mackensie (1985)
1985	Copenhagen	Denmark	Chemical Plant	Chlorine	0	8	0	Gronberg et al. (1994)
1985	Copenhagen	Denmark	Chemical Storage Plant	Orthocide 83 (83% captan - N-trichloromethyl-thiotetrahydrophthalimide)	0	0	No	Gronberg et al. (1994)
1985	Not Stated	India	Chemical Plant	Chlorine	1	153	No	TNO (1993)
1985	West Virginia	United States	Chemical Plant	Hydrogen chloride	0	0	No	Fishlock (1985)
1985	Cubatao	Brazil	Chemical Plant	Ammonia	0	300	Yes	TNO (1993)
1986	Zuid-Holland	The Netherlands	Chemical Plant	Ammonia	0	2	Yes	Wiersman et al. (1994)
1986	Alaska	United States	Transportation - Rail	Urea Formaldehyde	0	0	Yes	Anon. (1986e)
1986	Lake Nyos	Cameroon	Natural Disaster	Carbon dioxide	1,700	Not Stated	Not Stated	Kling et al. (1987)
1986	Basel	Switzerland	Chemical Plant	Phenol	0	0	No	Anon. (1986k)
1986	Varna	Bulgaria	Chemical Plant	Beryllium oxide	17	19	Not Stated	Anon. (1986j)
1986	Castleford	United Kingdom	Chemical Plant	Nitric acid	0	20	Not Stated	Anon. (1986l)

Year	Location	Country	Origin of Incident	Chemical	Deaths	Injuries	Evacuated	Reference
1987	Pittsburgh	United States	Transportation - Rail	Phosphorus oxychloride	0	14	Yes	Anon. (1987d)
1987	Bhopal	India	Chemical Plant	Ammonia	0	0	Yes	TNO (1993)
1988	New Hampshire,	United States	Chemical Plant	Hydrochloric acid	0	Not Stated	Yes	Anon. (1988l)
1988	Huelva	Spain	Chemical Plant	Chlorine	0	5	Yes	Vilchez Sanchez et al. (1995)
1988	Maine	United States	Chemical Plant	Chlorine dioxide	0	0	Yes	Anon. (1988b)
1988	Gueugnon	France	Chemical Plant	Ammonia	0	52	Not Stated	Brette et al. (1993)
1988	Indiana	United States	Chemical Plant	Hydrogen cyanide	5	30	Not Stated	Anon. (1995d)
1989	Ionava	Lithuania	Chemical Plant	Ammonia	7	57	Yes	Kukkonen et al. (1993)
1990	Constancia	Portugal	Water Treatment Works	Chlorine	0	10	No	Ventura et al. (1995)
1990	Michigan	United States	Chemical Plant	Hydrochloric acid	0	46	Yes	Anon. (1990b)
1991	Rotterdam	The Netherlands	Chemical Plant	Chlorine	0	31	No	Wiersman et al. (1994)
1991	London	United Kingdom	Other	Nitrogen dioxide	160	Not Stated	No	Thames Region Accident and Emergency Trainees Association (1996)
1991	Widnes	United Kingdom	Chemical Plant	Phosgene	0	60	No	Health & Safety Executive (1993)
1991	Botlek	The Netherlands	Chemical Plant	Chlorine	0	33	Yes	Wiersman et al. (1994)
1992	California	United States	Other	Microban (pesticide)	0	467	Yes	Sesline et al. (1994)
1992	Lisboa	Portugal	Chemical Plant	Chlorine	0	91	Yes	Ventura et al (1995)
1992	Paris	France	Transportation - Road	Boron trifluoride	0	0	Not Stated	Anon. (1992e)
1993	Swansea	United Kingdom	Transportation - Sea	Hydrogen sulphide	2	Not Stated	No	AWEHSP (1993)
1993	Frankfurt	Germany	Chemical Plant	O-nitroanisol	0	92	No	Heudorf et al. (1994)
1993	Matsumoto	Japan	Other	Potassium cyanide	7	60	No	Morita et al. (1995)
1993	California	United States	Transportation - Rail	Oleum (sulphuric acid)	0	24,000	No	Anon. (1993f)
1993	California	United States	Chemical Plant	Sulphuric acid	0	8000	No	Anon. (1993f)
1993	Kentucky	United States	Transportation - Rail	Vinylidene chloride	0	0	Not Stated	Anon. (1993a)
1994	London	United Kingdom	Natural Disaster	Aeroallergens	0	640	No	Thames Region Accident and Emergency Trainees Association (1996)
1994	Matsumoto	Japan	Malicious Act	Sarin	7	600	No	Morito et al. (1995)
1994	Doncaster	United Kingdom	Chemical Plant	Sulphur dioxide	0	22	Not Stated	Anon. (1994a)
1994	Ruabon	United Kingdom	Chemical Plant	Hydrogen sulphide	0	Not Stated	Not Stated	Anon. (1995f)
1994	Ellesmere Port	United Kingdom	Chemical Plant	Ethyl chloride	0	6	No	Anon. (1994h)
1995	Ruabon	United Kingdom	Chemical Plant	Hydrogen sulphide	0	200	No	Anon. (1995a)
1995	Tokyo	Japan	Malicious Act	Sarin	12	5,000	No	Taylor (1996)
1995	Derbyshire	United Kingdom	Chemical Plant	Sulphur trioxide	0	Not Stated	Not Stated	Anon. (1996k)
1995	Watford Gap	United Kingdom	Transportation -Road	Benzyl mercaptan	0	35	No	Harrison (1996)
1996	Shumerlya	Soviet Union	Transportation - Rail	Phenol (carbolic acid)	0	100	Not Stated	Anon. (1996f)
1996	Sant Celoni	Spain	Chemical Plant	Chlorine	0	72	No	Anon. (1993l)
1996	Swansea	United Kingdom	Other	Methyl styrene	2	250	No	Anon. (1996c)
1996	West Yorkshire	United Kingdom	Chemical Plant	Sulphuric acid	0	19	No	Anon. (1997a)
1996	Flix	Spain	Chemical Plant	Chlorine	0	2	No	Anon. (1996b)
1996	Montana	United States	Transportation - Rail	Chlorine	1	350	Yes	Kibble and Jones (1996)
1996	Frankfurt	Germany	Chemical Plant	Isoproturon	0	Not Stated	Not Stated	Anon. (1996g)
1997	Cleveland	United Kingdom	Chemical Storage Plant	Naphtha gas	0	1	Not Stated	Anon. (1997g)
1997	Hartlepool	United Kingdom	Chemical Plant	Titanium tetrachloride	0	0	No	National Focus (1997)

Twenty of the 80 incidents for which information was available resulted in deaths. Chlorine (N = 4) and ammonia (N = 3) were again frequently involved. Other chemicals included hydrogen and potassium cyanide, hydrogen sulphide and the most infamous of all, methyl isocyanate. However, it is difficult to present accurate figures on the numbers of deaths and injuries, as for many of the incidents, for example, Bhopal, there remain no definitive statistics (Mukerjee, 1995a).

Figure 3.8 Distribution of 82 airborne releases, by location of incident



Evacuations were ordered in 28 (47%) of the 59 incidents for which information was available. However, information on the actual numbers of people evacuated was only available in 17 (60%) of the incidents. These ranged from 200 to 220,000 in number, with chlorine (N = 5), ammonia (N = 3) and hydrochloric acid (N = 2) the main chemicals implicated. In a further 10 incidents, in-place sheltering was recommended.

<u>Chemical Spills</u>

Seventy-three (17% of the total) incidents involving chemical spills were identified by the review (see Table 3.12). Sixty-one were reported purely as chemical spills, 3 as chemical spills followed by explosions, 8 as chemical spills followed by fires, and 1 as a chemical spill followed by both explosion and fire. Seventy-eight per cent of the spills were transportation-related (Figure 3.9). Of these incidents, 39% occurred on the highway and 37% involved transport by rail. The remainder arose during transportation at sea (19%) or by pipeline (5%). Chemical plants were the locations for fourteen of the 16 incidents reported at fixed-facilities.

Information on the chemical(s) involved was available for 69 of the 73 incidents. A single chemical was implicated in 61 of the spills, which is predictable given the compartmentalisation of chemicals during transportation. Releases of more than one chemical either involved the derailment of a number of tank cars carrying different chemicals (N = 4) or the displacement of drums of varying chemical content from the flatbeds of lorries (N = 5) or the decks of ships (N = 1). A total of 84 different chemicals were spilled. Those that featured most commonly were crude oil (N = 7), toluene (N = 6), sulphuric acid (N = 5), acrylonitrile (N = 4), diesel oil (N = 4), petroleum (N = 4), sodium hydroxide (N = 4) and styrene monomer.

Deaths were reported in relation to 7 of the spills. However, as 4 involved single employees and were transportation-related, it is not clear whether the deaths were caused by injuries sustained in the course of the accidents or were due to exposure to the chemicals released. People were injured in 31 (56%) of the 55 incidents for which information was available. The population group most frequently injured were members of the public. However, with the exception of 4 incidents, which each gave rise to more than 200 casualties, the numbers injured were relatively small, when compared to those which followed many of the fire and explosion incidents. Injuries in emergency responders were reported following 10 of the spills. All were transportation-related (8 road; 2 rail) and involved exposure to very toxic chemicals, that is, acrylonitrile, hydrobromic acid, oleum (fuming sulphuric acid) and ethyldichlorosilane. Employees were injured in 9 of the incidents. Five of the incidents were transportation-related and involved single employees. The other four incidents occurred at chemical plants.

In spite of the small numbers of deaths and injuries, relative to the other types of incidents reviewed, 27 of the 56 spills for which information was available led to evacuations, 12 of which involved more than 1,000 members of the public. In-place sheltering was advised in a further 9 incidents.

The above results correlate well with the findings of other research undertaken into the frequency, nature and location of chemical spills, that is, most occur during the transportation of hazardous materials, chiefly flammable, corrosive and toxic substances (Arturson 1981; Quarentelli 1991; Lillibridge 1997). This is in spite of the introduction of international conventions and legislation, covering the safe transportation of dangerous goods (Smith and Purdy 1990; Schonfield *et al.* 1995).

In the UK, more than eighty million tonnes of chemicals are transported by road annually (Canadine 1990). As a result, any community that is near a railway, a highway, a commercial airport, or commercial shipping route is at risk from a chemical incident, and may suddenly be required to respond to a major emergency (Quarentelli 1991; Christie 1993; Campbell *et al.* 1993; Campbell 1994; Pearce 1996; Lillibridge 1997). This, in essence, is the problem with transportation-related incidents. They often arise in areas unprepared to deal with chemical incidents (Binder 1989). It also means that unlike the risk estimates and safety cases that can be prepared in relation to fixed facilities, the development of specific models of hazardous material transportation risks is very difficult.

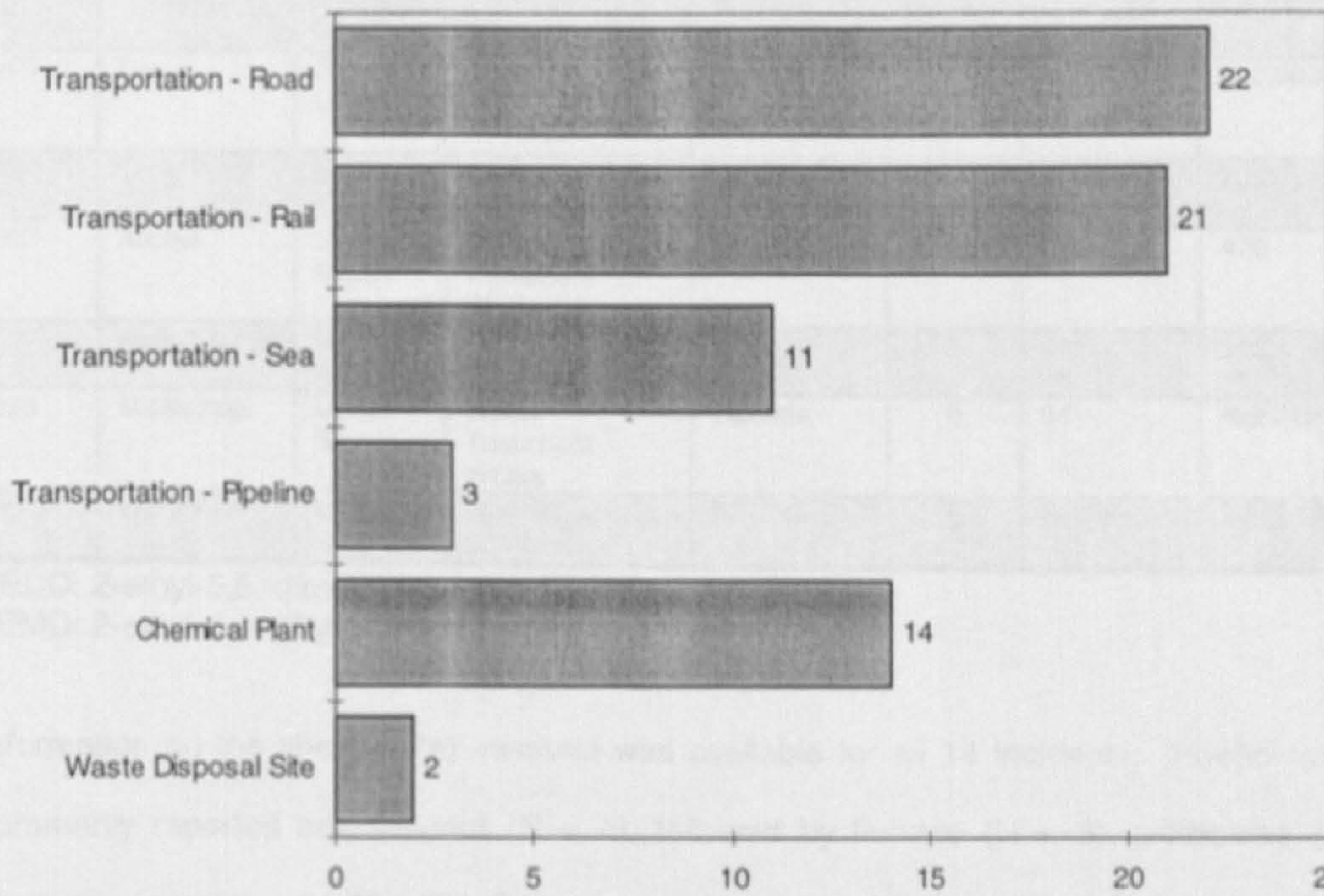
Table 3.12 Line-listing of 73 chemical spills identified by the literature review

Year	Location	Country	Origin of Incident	Chemical	Deaths	Injured	Evacuated	Reference
1979	Connecticut	United States	Chemical Plant	Chromium Wastes	0	0	Not Stated	Jones (1993)
1980	Massachussets	United States	Transportation - Rail	Phosphorus trichloride	0	343	Yes	Wason et al. (1984)
1981	Manitoba	United Stated	Transportation - Rail	Sodium hydroxide	0	Not Stated	Not Stated	Anon. (1992c)
1981	Oklahoma	United States	Transportation - Rail	Toluene	0	0	Yes	Anon. (1981a)
1981	Heiligenkreuz	Austria	Transportation - Road	Methyl furan	0	Not Stated	Not Stated	Anon. (1982f)
1981	Texas	United States	Transportation - Rail	Butyl alcohol	0	0	Yes	Anon. (1981c)
1981	San Francisco	United States	Chemical Plant	Silicon tetrachloride	0	28	Yes	Kizer et al. (1984)
1982	Louisiana	United States	Transportation - Rail	Vinyl chloride monomer	0	0	Yes	Anon. (1983d)
1982	Pennsylvania	United States	Transportation - Road	Not Stated	0	Not Stated	Yes	Anon. (1982g)
1982	Texas	United States	Transportation - Sea	Acrylonitrile	0	Not Stated	Not Stated	Anon. (1982d)
1982	Louisiana	United States	Transportation - Pipeline	Sulphuric acid	0	Not Stated	No	Anon. (1982e)
1982	Louisiana	United States	Transportation - Rail	Ammonium thiosulphate	0	0	No	Anon. (1982h)
1982	California	United States	Transportation - Road	Dichloropropanol	0	0	Not Stated	Anon. (1982b)
1983	Denver	United States	Transportation - Rail	Nitric acid	0	43	Yes	Anon. (1993c)
1984	Summit Tunnel	United Kingdom	Transportation - Rail	Petroleum	0	Not Stated	Yes	Smith and Purdy (1990)
1984	Ontario	Canada	Transportation - Rail	Sulphuric acid	0	0	Not Stated	Anon. (1984c)
1985	Philadelphia	United States	Transportation - Road	Sodium hydroxide	0	3	Not Stated	Promisloff et al. (1990)
1985	Ontario	Canada	Transportation - Rail	Sodium hydrogen sulphite	0	Not Stated	No	Anon. (1986f)

Year	Location	Country	Origin of Incident	Chemical	Deaths	Injured	Evacuated	Reference
1985	West Virginia	United States	Transportation - Road	Antimony pentachloride	0	12	Yes	Anon. (1986m)
1986	Cleveland	United Kingdom	Transportation - Road	Toluene	0	0	No	Smith and Purdy (1990)
1986	British Columbia	Canada	Transportation - Rail	Ethylene dichloride	0	0	No	Anon. (1986n)
1986	Hull	United Kingdom	Transportation - Sea	Gramoxone (paraquat)	0	Not Stated	Not Stated	Collins (1996)
1986	Ludwigshafen	Germany	Chemical Plant	Dichlorophenoxy acid	0	0	No	Anon. (1986l)
1986	Hull	United Kingdom	Transportation - Road	Diphenylmethane di-isocyanate	0	4	Not Stated	Anon. (1986c)
1986	Sheffield	United Kingdom	Chemical Plant	Solvent	0	0	Yes	Anon. (1986g)
1986	Segovia	Spain	Transportation - Road	Oleum (sulphuric acid)	3	1	No	Vilchez Sanchez et al. (1995)
1986	Hamilton	Canada	Chemical Plant	Not Stated	0	32	Not Stated	Anon. (1986e)
1986	Oklahoma	United States	Chemical Plant	Uranium hexachloride	1	100	No	Anon. (1986p)
1987	Southampton	United Kingdom	Transportation - Road	Isopropyl alcohol	0	Not Stated	Yes	Smith and Purdy (1990)
1987	Texas	United States	Chemical Plant	Hydrofluoric acid	0	939	Yes	Dayal et al. (1994)
1987	Doncaster	United Kingdom	Transportation - Road	Toluene	0	0	No	Anon. (1987b)
1987	Aveiro	Portugal	Chemical Plant	70 % solution of phosgene in monochlorobenzene	0	9	No	Ventura et al. (1995)
1987	Hertfordshire	United Kingdom	Transportation - Road	Red lead oxide	0	79	No	Faulkener (1987)
1988	Moscow	Soviet Union	Transportation - Rail	Not Stated	0	34	Yes	Anon. (1988d)
1988	Flaxweiler	Luxembourg	Transportation - Pipeline	Kerosene	0	0	No	Behaegel et al. (1995)
1988	Walton-on-Thames	United Kingdom	Transportation - Road	Petroleum	0	1	Yes	Smith and Purdy (1990)
1988	North Sea	North Sea	Transportation - Sea	Acrylonitrile	4	0	No	Gronberg et al. (1994)
1988	Sheffield	United Kingdom	Other	Toluene	0	Not Stated	Not Stated	Anon. (1988g)
1989	Picoto	Portugal	Transportation - Road	Petroleum	0	11	Yes	Ventura et al. (1995)
1989	Roye / Peronne	France	Transportation - Road	Potassium cyanide	0	2	No	Behaegel et al. (1995)
1989	Quebec	Canada	Transportation - Rail	Sodium hydroxide	0	Not Stated	Yes	Anon. (1990a)
1989	Sines	Portugal	Transportation - Sea	Heavy crude oil	0	0	No	Ventura et al. (1995)
1989	Alaska	United States	Transportation - Sea	Crude oil	0	Not Stated	No	Anon. (1989h)
1990	Ekeren	Belgium	Transportation - Rail	Dimethyl ether	0	0	Yes	Behaegel et al. (1995)
1990	London	United Kingdom	Transportation - Road	Ethyldichlorosilane	0	14	No	Thanabalasingham et al. (1991)
1990	Luton	United Kingdom	Transportation - Road	Hydrobromic acid	0	15	Not Stated	Anon. (1991f)
1990	California	United States	Transportation - Sea	Crude oil	0	0	No	Gellert et al. (1994)
1990	Maizieres-Les-Metz	France	Transportation - Road	Ethyl acrylate	0	1	Not Stated	Brette et al. (1993)
1990	Martelange	Luxembourg	Transportation - Road	Monochloracetic acid	1	1	No	Behaegel et al. (1995)
1991	Kinkempois	Belgium	Transportation - Rail	Acrylonitrile	0	20	Not Stated	Behaegel et al. (1995)
1991	Alava	Spain	Chemical Plant	Oleum (sulphuric acid)	0	0	Yes	Vilchez Sanchez et al. (1995)
1991	California	United States	Transportation - Rail	Metam sodium	0	220	Yes	Bowler et al. (1994)
1992	Wisconsin	United States	Transportation - Rail	Benzene	0	25	Yes	Reisch (1992)
1992	Maydown	United Kingdom	Chemical Plant	Chlorobutadiene	0	Not Stated	No	Anon. (1992g)
1992	Attica	Greece	Chemical Plant	Petroleum	1	33	No	Ziomas et al. (1994)
1992	Toledo	Spain	Transportation - Road	Toluene	0	1	Yes	Vilchez Sanchez et al. (1995)
1992	Naestved	Denmark	Transportation - Rail	Acrylonitrile	0	26	No	Gronberg et al. (1994)
1992	La Coruna	Spain	Transportation - Sea	Crude oil	0	5	Yes	Vilchez Sanchez et al. (1995)
1993	Tarragona	Spain	Transportation - Sea	Naphtha	0	0	Yes	Vilchez Sanchez et al. (1995)
1993	Indiana	United States	Transportation - Pipeline	Toluene	0	0	Not Stated	Anon. (1993e)
1993	Shetland Is.	United Kingdom	Transportation - Sea	Crude oil	0	230	No	Campbell et al. (1993)
1993	Not Stated	Pakistan	Chemical Plant	M-dinitrobenzene	2	Not Stated	No	Haines (1993)
1994	California	United States	Transportation - Road	Acetic acid	2	1	Yes	Haines (1994)
1994	Lausanne	Switzerland	Transportation - Rail	Epichlorohydrin	0	0	Not Stated	Anon. (1994d)

Year	Location	Country	Origin of Incident	Chemical	Deaths	Injured	Evacuated	Reference
1994	Lausanne	Switzerland	Transportation - Rail	Not Stated	0	0	Yes	Anon. (1994d)
1995	London	United Kingdom	Transportation - Road	Unsaturated polyester resin	0	Not Stated	Not Stated	Department of Health (1996)
1995	Sussex	United Kingdom	Chemical Plant	Hydrochloric acid	0	3	No	Anon. (1995e)
1996	Milford Haven	United Kingdom	Transportation - Sea	Crude oil	0	Not Stated	0	Anon. (1996l)
1996	Gothenburg	Sweden	Transportation - Road	Ethylendiamine	0	0	Not Stated	Anon. (1996d)
1997	Mississippi	United States	Transportation - Rail	Chloroprene	0	0	Yes	Anon. (1997d)
1997	Mikuni	Japan	Transportation - Sea	Crude oil	0	13	No	Anon. (1997h)
1997	Glasgow	United Kingdom	Water Treatment Works	Diesel oil	0	Not Stated	No	Anon. (1997i)
1997	Edinburgh	United Kingdom	Water Treatment Works	Diesel oil	0	Not Stated	No	Anon. (1997j)

Figure 3.9 - Distribution of 73 chemical spills, by location of incident



Water Contamination Incidents

A total of 14 water contamination incidents (4% of the total) were identified by the review (see Table 3.13). The causes of the incidents comprised contamination of source waters (N = 9; all following spills: five at chemical plants, two arising from agricultural activities, one at a waste disposal site and one transportation-related); operational error during water treatment (N = 4); (3 involving fluoride overdosing and the other, accidental contamination of post-treatment supplies); and chemical contamination of water with a boiler additive at a school.

Table 3.13 - Line-listing of 14 water contamination incidents identified by the literature review

Year	Location	Country	Origin of Incident	Chemical	Deaths	Injuries	Population at Risk	Reference
1974	Wisconsin	United States	Transportation - Rail	Phenol	0	Not Stated	26 households	Baker et al. (1978)
1976	Tennessee	United States	Agriculture	Chlordane	0	13	105	Harrington et al. (1978)
1978	New Mexico	United States	Water Treatment Works	Fluoride	0	34	265	Hoffman et al. (1980)
1979	New York	United States	Agriculture	Aldicarb	0	Not Stated	Not Stated	Haines (1994)
1984	River Dee	United Kingdom	Chemical Plant	Phenol	0	Not Stated	2,000,000	Jarvis et al (1985)
1987	Ontario	Canada	Chemical Plant	Nickel	0	20	43	Sunderman et al. (1988)
1987	Shanxi Province	China	Chemical Plant	Ammonium hydrogen carbonate	0	20,000	Not Stated	Mann (1987)
1988	Lowermoor	United Kingdom	Water Treatment Works	Aluminium sulphate	0	Not Stated	20,000	Rowland et al. (1990)
1990	Ufa	Soviet Union	Chemical Plant	Phenol	0	Not Stated	600,000	Murray and James (1990)
1991	Teagu City	Korea	Chemical Plant	Phenol	0	Not Stated	2,000,000	Kim et al. (1994)
1992	Alaska	United States	Water Treatment Works	Fluoride	1	296	470	Gessner et al. (1994)
1992	New Jersey	United States	School	Nitrite	0	29	312	Askew et al. (1994)
1993	Mississippi	United States	Water Treatment Works	Fluoride	0	54	Not Stated	Penman et al. (1993)
1994	Worcester	United Kingdom	Waste Disposal Site	EDD/EMD*	0	Not Stated	140,000	Fowle et al. (1994)

* EDD: 2-ethyl-5,5,-dimethyl-1,3-dioxane
EMD: 2-ethyl-4-methyl-1,3-dioxolane

Information on the chemical(s) involved was available for all 14 incidents. Phenol was the most commonly reported contaminant (N = 4), followed by fluoride (N = 3), pesticides (N = 2) and aluminium compounds (N = 2). Only one death was recorded, and in only 2 of the 7 incidents for which information was available, were more than 100 people reported as suffering with symptoms. However, in all 12 of the incidents for which information was available, large populations were potentially place at risk, as shown in Table 3.13.

Special Features of Water Contamination Incidents

From the review undertaken, and those of others (Young *et al* 1996), it would therefore appear that incidents which result in the acute chemical contamination of drinking water supplies are reassuringly rare. The data on deaths and injuries also suggests that they present a lesser risk to human health than other types of incidents. This is probably because most chemical contaminants are readily detectable by smell or taste, and thus people usually refrain from consuming water containing them (World Health Organisation 1997).

However, water contamination incidents, when they arise, do assert special requirements on water companies and other agencies, including public health professionals. Alternative water supplies may need to be provided, public information rapidly disseminated, and immediate health risk assessments instigated (Mayon-White 1993). Additionally, even where minimal acute health effects have been reported in populations affected by contaminated water supplies, there is evidence to suggest that such incidents do give rise to real mental and physical suffering in the community, attributed to anxiety and heightened awareness, rather than to any toxic effect (Department of Health 1991; Clarke, 1993; Fowle *et al.* 1994). Increasing attention may therefore need to be paid by public health professionals to the psychosocial aspects of acute chemical incidents (Bertazzi 1989a; Baxter 1993).

Food Contamination Incidents

Incidents may also occur which are not related to industry or transport (Gunnell 1993). The food chain may be endangered by the direct use of chemicals in the handling and processing of food (Bertazzi 1989), or indirectly through accidental releases and waste disposal activities (Travis and Arms 1987). Twenty-one incidents of food contamination were identified by the review (Table 3.14). Bar three, all originated as a result of agricultural practices (N = 8) or in commercial food production (N = 10). Pesticides were implicated in 5 of the agriculture-related incidents. More than 1,000 people were affected in each of 8 incidents, confirming that when food contamination occurs, large numbers of people may potentially be at risk.

Table 3.14 Line listing of 21 Food Contamination Incidents identified by the literature review

Year	Location	Country	Origin of Incident	Chemical	Deaths	Injuries	Population at Risk	Reference
1955 - 1961	South East Turkey	Turkey	Agriculture	Hexachlorobenzene	400 - 500	4,000 - 5,000	Not Stated	Cripps et al (1984)
1956	Minimata Bay	Japan	Chemical Plant	Methylmercury	1,043	1,209	2,252	Harada (1995)
1965	Epping	United Kingdom	Commercial - Bakery	4,4-methylene dianiline	0	84	Not Stated	Kipelman et al. (1966)
1968	Fukuoka	Japan	Commercial - Food oil manufacturer	Poly-chlorinated biphenyls	22	1,057	Not Stated	Kuratsune et al. (1972)
1971 - 1972	Iraq	Iraq	Agriculture	Methylmercury	459	6,530	Not Stated	Damluji et al. (1972)
1973 - 1974	Michigan	United States	Agriculture	Poly-brominated biphenyls	0	333	4,000	Rogan (1996)

Year	Location	Country	Origin of Incident	Chemical	Deaths	Injuries	Population at Risk	Reference
1978	Taiwan	Taiwan	Commercial - Food oil manufacturer	Poly-chlorinated biphenyls	0	2,000	Not Stated	Chen (1994)
1981	Madrid	Spain	Commercial - Food oil manufacturer	Not Known	340	20,000	60,000	Haines (1993)
1985	Colonia City	Uruguay	Commercial - Bakery	Potassium bromate	0	35	Not Stated	Alonzo (1993)
1985	California	United States	Agriculture	Aldicarb	6	1,350	Not Stated	Haines (1994)
1986	Sierra Leone	Africa	Commercial - Bakery	Parathion	14	35	Not Stated	Hill et al. (1990)
1987	Kashmir Valley	India	Agriculture	Trichothecene mycotoxins	0	97+	Not Stated	Bhat et al. (1989)
1988	Buenos Aires	Argentina	Malicious Act	Arsenic	0	400	Not Stated	Haines (1994)
1990	London	United Kingdom	Other - School	Pesticide	0	53	468	Aldous et al. (1994)
1992	Not Stated	Republic of Ireland	Agriculture	Aldicarb	0	50	Not Stated	Aldous et al. (1994)
1992	Mercedes City	Uruguay	Commercial - Bakery	Potassium bromate	0	29	Not Stated	Alonzo (1993)
1992	San Jose	Uruguay	Commercial - Bakery	Potassium bromate	1	6	Not Stated	Alonzo (1993)
1992	Catalonia	Spain	Agriculture	Clenbuterol	0	113	Not Stated	Salleras (1995)
1992	Farkhar	Tadjikistan	Agriculture	Pyrrolizidine alkaloid	0	3,906	10,000	Chavin et al. (1993)
1993	Not Stated	Argentina	Commercial - Wine producer	Methanol	27	200	Not Stated	Haines (1993)
1997	Manchester	United Kingdom	Commercial - Butcher	Sodium nitrate	0	3	Not Stated	Bacon (1997)

Special Features of Food Contamination Incidents

One of the most serious incidents of this type occurred in May 1981, when an epidemic of a previously undescribed illness presented itself in Spain. By the end of 1982, the disease, officially called "toxic oil syndrome", had affected some 20,000 people with over 350 deaths (Anon. 1983a).

Of particular interest in this epidemic, and likewise in an outbreak of 84 cases of jaundice that occurred in Epping, London in February 1965 (Kopelman *et al.* 1966; Hall *et al.* 1992), was that an infective cause was initially suspected. However, the epidemiological evidence provided by a series of case-control studies supported the hypothesis that cooking oil was responsible for transmitting the causative agent of toxic oil syndrome (Canas and Kilbourne 1987; Diaz de Rojas *et al. 1987)*. Consequently, 38 Spanish oil merchants were put on trial in July 1987 charged with public health offences and fraud; all were found guilty and convicted (Ortega-Benito 1992). The benefits of epidemiological studies were therefore extolled.

However, despite the apparent relation to the consumption of an illegally marketed cooking oil, the causative agent is as yet undetermined. Although aniline contamination of suspect oils was common, and a clear dose-response relationship was demonstrated (Kilbourne *et al.* 1988), the clinical picture of "toxic oil syndrome" was distinct from that of aniline toxicity. Additionally, anilides found in the oil did not induce the same syndrome in animals (Anon 1983a; Toxic Epidemic

Syndrome Study Group 1982). The incident has therefore left a dilemma which concerns all countries. With the precise cause of the disease still unknown, no assurance can be given that it will not happen again (Anon. 1983a).

Cooking oil has also been implicated in two other outbreaks of mass food poisoning. In October 1968, an epidemic of an unusual skin disease similar to chloracne began to be reported in Japan (Kuratsune *et al.* 1972). By August 1971, the disease had produced 1,057 patients. The cause was attributed to the ingestion of rice oil contaminated with polychlorinated biphenyls (PCBs), and the disease christened "Yusho", namely oil disease. Kuratsune *et al.* in their paper, believed that reporting their experiences would help many people in the world who were concerned about the chronic deleterious effects of PCBs (Kuratsune *et al.* 1972). Between June 1978 and October 1979, however, history repeated itself when more than 2,000 people in Taiwan consumed rice bran oil contaminated with heat-degraded PCBs (Hsu *et al.* 1994).

The afore-mentioned poisonings happened as a result of the accidental contamination of foodstuffs. Major outbreaks have, however, also occurred following the use of chemical fungicides as seed dressings (mainly of wheat seedlings). In Iraq, three epidemic poisonings were reported between 1955 and 1972, caused by the distribution of seed grain treated with alkylmercury compounds (Damiuji and Tikriti 1972). The total number of official cases stands at 6530, including 459 deaths (Watanabe and Satoh, 1996). A major factor contributing to the size of the epidemic was the unusually long latency period of up to 60 days between exposure and the onset of symptoms.

Similarly, in south-east Turkey between 1955 and 1961, three thousand people developed *porphyria turcica,* due to ingestion of hexachlorobenzene, a fungicide added to wheat seedlings (Cripps *et al.* 1984). Due to its late arrival, the shipped seed was used to replace edible stores of wheat, as bread or bulgar. The condition became known as "black sore", although many of the breast-fed children under the age of 1 year died from a disease known as "pink sore".

Adulteration of alcoholic beverages with methanol and ethylene glycol have been other commonly reported causes of chemical disasters involving food (Haines 1994).

Consumer Products

It was also felt important to raise awareness in this review that chemical incidents may also arise through the use of other products, which the general public normally regard as safe. In August 1981, paediatric hospitals in Ho Chi Minh City, Vietnam, began to report cases of a haemorrhagic syndrome in children (Martin-Bouyer *et al.* 1983). A retrospective epidemiological investigation identified the cause as talcum powder contaminated with the anticoagulant warfarin (Martin-Bouyer *et al.* 1984). 177 children died and a further 564 were affected. The possibility of intentional adulteration of the talcum powder has not been ruled out. Above all, the incident demonstrated the significant potential for transcutaneous uptake of warfarin.

Chemical Terrorism

Chemical terrorism has long been used to achieve political and military objectives (Lillibridge 1997). Modern chemical weapons date from World War 1, which brought us chlorine gas and mustard gas (Baskerville 1919), and they have grown ever more deadly. Just before World War 2, German scientists developed the first nerve gas, tabun, which led to deadlier agents called sarin and VX. For a fuller account of the biological / physical properties of chemical agents, see Carnes and Watson (1989) and Sidel (1990).

International conventions have long prohibited the use of chemical weapons during war (Hu *et al.* 1989; Carnes and Watson 1989). In spite of this, the US budget for chemical warfare programmes for the period 1982 through 1991 has been estimated at $6.6 billion (Sidel 1989). Concerns have also been raised by the alleged use of tricothecene toxins and other combinations of chemical agents in Laos and Kampuchea in the late 1970s - The "Yellow Rain" Affair; and, mustard gas by Iraq during its war with Iran and against its Kurdish population in 1988 (Hu *et al.* 1989;Sidel 1989).

Small-time terrorists are also getting involved. On 27 June 1994, 12 litres of the nerve agent sarin (isopropyl methyl phosphonofluoridate) were released by the Aum cult terrorists in Matsumoto city, Japan, using a heater and fan from a truck (Morita *et al.* 1997). Seven people were killed, and about 600 residents and rescue staff affected by the agent. Of the 52 rescuers who came to the assistance of victims, 18 suffered symptoms.

A second incident with sarin occurred in the Tokyo subway on 20 March 1995. The Aum Shinrikyo cult were again responsible for the act of terrorism, which left 12 people dead and 5,000 injured. In the aftermath of the attack, calls were made for public health authorities and emergency services to start planning now for future incidents. In particular, concerns were expressed in this incident, as with that at Matsumoto, regarding the numbers of rescuers who were affected by the toxic vapour. Programmes were urgently needed to protect rescuers from poisoning (Nakajima *et al.* 1997).

Natural Disasters

Certain natural phenomena may also resemble chemical releases from industrial sites. For example, in the mid-1980s, the country of Cameroon was twice struck by unusual natural disasters, involving the release of lethal carbon dioxide gas from crater lakes. The first of these disasters occurred at Lake Monoun on 15 August 1984, and resulted in 37 deaths (Sigurdsson *et al.* 1987). The second occurrence was however much more disastrous. A cloud of 1.0 km^3 of carbon dioxide gas, released from Lake Nyos on 21 August 1986, caused death by asphyxiation of 1,700 people and 3000 cattle (Kling *et al.* 1987; Palca 1987).

The likelihood that natural disasters may give rise to secondary chemical incidents is also increasing, with technological expansion (Binder and Sanderson 1987; Showalter and Myers 1994; Lillibridge 1997; Nantel 1998). For example, in "Silicon Valley' in California, preparedness plans have been developed to take account of the devastating toxic exposures which may result from the destruction of pipelines and hazardous material storage containers, in the event of an earthquake (Binder and Sanderson 1987).

Natural Toxins

Natural toxins may be of animal, plant or microbial origin (Haines 1994). Examples include:

(a) Pyrrolizidine alkaloids

Several outbreaks of veno-occlusive disease have been reported - Afghanistan, 1975 (Mohabbat *et al.* 1976), India, 1977 (Tandon *et al.* 1977); and Tadjikstan, 1992 (Chauvin *et al.* 1993). The cause is a pyrrolizidine alkaloid found in the seeds and roots of weeds, such as *Heliotropium lasocarpium.*

In the Tadjikstan outbreak, a famine led to a delay in the wheat harvest. This gave time for the weed to grow and go to seed. When the wheat was eventually harvested, heliotrope seeds containing the deadly alkaloid were also ground into flour to make bread. Six weeks later, the first case of liver toxicity was reported. Between October 1992 and March 1993, 3906 cases occurred, with a case fatality ratio of 1.3%. In spite of international efforts to increase the awareness of local populations at an early stage in such outbreaks, political and economic difficulties in such countries often preclude compliance with public health advisories (Chauvin *et al.* 1993).

(b) Red Tides

Red tides are a natural coastal phenomenon, found to be prevalent in most parts of the world (Hartigan-Go and Bateman 1994). They are caused by sudden population growths of minute marine organisms called dinoflagellates. Consumption of shellfish contaminated with neurotoxins released from particular species of dinoflagellates may lead to the development of neurological and gastrointestinal symptoms in humans, a condition commonly referred to as "paralytic shellfish poisoning".

Redtides have been known to cause deaths of sea birds and fish in the United Kingdom (Clark 1994), but active surveillance of coastal waters during the summer months and routine shellfish sampling programmes have generally been effective in preventing outbreaks of human PSP. Worldwide, however, it has been estimated that 1,600 cases of PSP occur each year (Halstead and Schantz 1984). Between 1983 and 1991, 18 outbreaks of PSP occurred in the Philippines alone (Hartigan-Go and Bateman 1994). More than 1,300 cases were reported, with 50 deaths. In Guatemala, 187 people were affected with

PSP between July and August 1987 (Rodrigue *et al.* 1990). A case study implicated a species of clam as the vehicle of the neurotoxin. Twenty-six people died.

It is interesting to note again the influence of economic pressures over health and safety issues even when bans on shellfish have been imposed. Hartigan-Go and Bateman (1994) considered, in such circumstances, that:

> ... a source of economic relief (was) essential to obtain the co-operation of fishermen and market vendors to comply with the ban.

(c) Trichothecene mycotoxicosis

During June to September 1987, several thousands of people residing in the Kashmir Valley of India were affected by an outbreak of a gastrointestinal disorder (Bhat *et al.* 1989). Epidemiological investigations and animal studies confirmed the cause to be due to the consumption of bread made from mould-damaged wheat. In samples tested, varying quantities of trichothecene mycotoxins, probably released by moulds belonging to the genus *Fusarium*, were identified. Other outbreaks of mycotoxicoses have taken the form of ergotism (Krishnamachari and Bhat 1975) and aflatoxicoses (Ngindu *et al.* 1982).

It should also be noted that mouldy agricultural products may also cause allergenic (for example, farmer's lung disease) and non-allergenic respiratory illnesses (for example, organic dust toxic syndrome) (Dan 1987). An outbreak of the latter occurred in 1986 among members of a college fraternity in the US, following a party in the basement of a property, the floor of which had been covered with 6 - 8 inches of mouldy straw (Brinton *et al.* 1987).

Conclusions

Through reviewing the literature, 9 chemical incident databases were identified. All were found to focus mainly on the causes and the immediate losses from an industry perspective, which reflected their primary purpose, that is, of guiding risk assessment decisions in relation to major hazard planning and management. The accuracy of death and injury information was also questionable, with little evidence of data validation. The development of a system of simply logging data on incidents in Wales picked up through the media or other sources was therefore unlikely to enable analysis of any associations between mortality and morbidity and various risk factors, such as location of incident. However, it was recognised that such databases might provide a useful check on the sensitivity of any surveillance system developed.

Although limited in their numbers, three of the 4 surveillance systems identified by the review provided useful guidance for the development of the surveillance system in Wales. The US ATSDR HSEESS was particularly instructive in emphasising the benefits of employing an active system of surveillance, and also in identifying factors to be considered in the design of appropriate data analysis routines. The "Environmental Health Incident Notification System" in Scotland highlighted the importance of information dissemination from any surveillance system, whilst the system adopted by the UK Fire Service stressed the need for both piloting of the system and the development of rigorous data validation regimes.

The review of individual chemical incident reports highlighted the lack of published material within the scientific peer-reviewed literature. The majority of reports were anecdotal commentaries in news journals, and summaries within published reports. The quality of the data reported on incidents was therefore variable and not validated. However, the analysis undertaken of the reports, on both a combined and specific basis, did highlight the types of routines that might prove to be beneficial in investigating factors associated with the public health consequences of acute chemical incidents.

The review has therefore confirmed that in order to accurately define the size of the problem of acute chemical incidents within any geographically defined area, a public health surveillance system is required.

Chapter 4 - Background to the Development of the Surveillance System for Wales

Introduction

The literature review has provided guidance for the development of a multi-agency geographically defined surveillance system for acute chemical incidents in Wales. The review has also discussed many of the challenges that public health professionals face in handling such events. The aim of this Chapter is to set the political, legislative and organisational context within which the surveillance system evolved in Wales.

This will begin with an examination of the arrangements that were in place in Wales in the early 1990s for the inter-agency management of acute chemical incidents.

Arrangements for the Response to Acute Chemical Incidents in Wales

Introduction

In 1990, a report commissioned by the Commission of the European Communities (CEC) concluded that arrangements in the United Kingdom (UK) for responding to and managing chemical incidents were generally very effective (Smith and Purdy 1990). The UK approach, and therefore the Welsh approach, to managing chemical incidents, at this time, was principally characterised by the partnership between a number of key players at the local level (Smith and Purdy 1990); these included the emergency services, local authorities, health authorities, the chemical industry and other agencies.

The first principle of national policy, was that there was no single agency with all the skills and resources needed to deal with a chemical incident. Moreover, a Home Office review in 1989 concluded that:

> ... the disaster response would not be helped by the creation of anything in the nature of a national disaster squad; prime responsibility for handling disasters should remain at the local level where the expertise and resources are found.
>
> (Home Office 1989)

The second principle was that to achieve maximum effectiveness, the different agencies and authorities involved all needed to adopt, and aim to work within, the framework of "Integrated Emergency Management" (IEM) (Home Office 1992).

The key features of the IEM process were:

(a) Full involvement at the planning stages for all key organisations

(b) Integrated training

(c) Clear defined roles for all organisations

(d) Identified resources (Home Office 1992).

Legislation relevant to Emergency Response

By the early 1990s, a large amount of legislation had been enacted in the UK, both for the prevention of chemical incidents, and for the development of plans to minimise effects in the event of an incident. In particular, the occurrence of disasters at Flixborough, Seveso, Basle and Bhopal, had directly led to the imposition of formal systems of legislative control on owners of industrial installations producing and storing chemicals. However, the control systems introduced had been, on the basis of "major hazard" potential, largely selective in their application to different substances and different processes (Health and Safety Executive 1985).

There was also in existence a number of semi-legal guidance documents, in the guise of circulars, which had been issued by Welsh Office to health authorities in Wales.

Central Government Departments

As stated above, fundamental to the arrangements for dealing with chemical incidents in Wales, at this time, was that the first response remained at the local level. However, it was also recognised that central government had a role to play. Hence, in the event of a major incident occurring within the principality, a Welsh Office Department could, where appropriate, take the lead. In such circumstances, the role of the "lead department" was: (a) to co-ordinate the activities of other departments in Welsh Office in discharging their own specific responses to an incident, and (b) to gather information for the purposes of briefing ministers, informing Parliament and providing information to the public and the media on a national basis.

In the case of an extremely severe incident, Welsh Office could also declare a "National Emergency". This did not, however, mean that the management of the incident passed to a central body. The aim of such a declaration was to facilitate the mobilisation of national support to the locality affected. Additionally, in specific cases, Welsh Office had the ability to reimburse local authorities and other agencies for some or all of the costs incurred in dealing with such an incident (Smith and Purdy 1990).

Local Authorities

Following the reorganisation of local government in Wales in 1974, the principal councils comprised of 8 county councils and 37 non-metropolitan district councils, although emergency planning was essentially a function of the former authorities. The general approach taken by the county councils to emergency planning was one of "all hazards", that is, the development of flexible plans tailored to meet all the problems which were perceived to exist or might arise within their respective areas (Smith and Purdy 1990). They were also mandatorily required to prepare off-site emergency plans for designated classes of industrial installations, that is, those subject to the requirements of the Control of Industrial Major Accident Hazards Regulations 1984 (CIMAH) (Health and Safety Executive 1985).

The Emergency Services (Fire and Police)

The legal basis for the involvement of the fire service in dealing with chemical incidents had been enacted some years' previous, in the Fire Service Act 1947. In the early 1990s, fire services were provided by 8 brigades in Wales, operating on boundaries coterminous with the county councils, and under the direct administration of those authorities.

In relation to chemical incidents, the police had powers similar to those of local authorities. These were primarily under the Civil Defence Act 1948 and the Civil Protection in Peacetime Act 1986. The police were organised into four constabularies in Wales.

Health and Safety Executive

The Health and Safety Executive (HSE), established in 1974 as a non-departmental public body, was responsible for the enforcement of health and safety legislation at most industrial sites in Wales. Of particular relevance to its activities was the following legislation:

Health and Safety at Work etc. Act 1974 (HSWA)

The HSWA imposed general duties, at all work premises, on employers towards employees and others, including members of the public off-site, to ensure that they were protected from risks arising from their activities.

The Notification of Installations Handling Hazardous Substances Regulations 1982 (NIHHS)

The first set of regulations enacted under HSWA were NIHHS (Health and Safety Executive 1982). Under NIHHS, operators of sites where certain hazardous materials were stored or handled, in quantities greater than a specified threshold, were required to provide details of their operations to HSE. The quantities notified were then used to consider the suitability of land use planning proposals within a set distance around the plant, known as the "consultation distance".

When developments were proposed within the "consultation distance", the local authority planning department consulted HSE for an opinion on the risk which would be presented to people by the development, if it was permitted. The "consultation distance" was also used by HSE to set the area in which a top tier "major hazard" site was to provide information to the public in the event of a major accident.

The Control of Industrial Major Accident Hazard Regulations 1984 (CIMAH)

The CIMAH Regulations were designed to prevent, or mitigate the effects of, major accidents to both people and the environment (Health and Safety Executive 1985). Industrial activities falling within the scope of the regulations were defined in terms of storage and processes involving specified dangerous substances. The requirements operated at two levels or tiers. The lower tier requirements were widely applied and required the person in control to:

(a) report major accidents to the HSE; and

(b) where required, demonstrate to HSE that the plant was being operated safely.

More specific requirements applied to potentially more hazardous installations and required the person in control, in addition to the above, to:

(a) submit a safety report to HSE which identified the nature and use of dangerous substances at the site, identified how major accidents could possibly occur and described the arrangements in place to prevent, control or mitigate them;

(b) prepare an on-site emergency plan; and

(c) provide information to the public about the major hazards on-site and their dangers, and what to do in the event of an emergency.

As stated above, local authorities were also required by CIMAH to prepare an off-site emergency plan. In this respect, the HSE's interest in off-site planning extended to the adequacy of the information given by hazardous installations to local authorities and to ensuring that the latter prepared and kept the plans up to date.

The Dangerous Substances in Harbour Regulations 1987 (DSHAR), which were very similar in their requirements to the CIMAH Regulations, applied to port and harbour areas (Health and Safety Executive 1987).

The Planning (Hazardous Substances) Regulations 1992

These regulations placed further controls on hazardous developments. They were administered by the Hazardous Substance Authority (HSA), usually the local authority planning department. If a company wished to handle specified quantities of certain substances, it had to apply to the HSA for consent to do so, irrespective of whether or not planning permission was also required.

Although there was no explicit mention of chemical incidents in the COSHH Regulations, the accompanying Approved Code of Practice (ACOP) (Health and Safety Executive 1988) made it quite clear that an employer was expected to consider foreseeable emergencies and to plan for them (Hayes 1991).

In complying with the ACOP, employers were required to ensure that, on arrival at a site, visiting members of the emergency services (in particular, fire-fighters) were made aware of any substances on the premises which offered a significant risk to their health. They were also required to have the necessary means available to limit the extent of risks to their health and to regain adequate control of the site, in the event of a leak, spill or uncontrolled release of a hazardous substance. Such means were expected to include sufficient and suitable personal protective equipment to enable the source of the release to be safely identified and repairs to be made, together with established procedures for the safe disposal of the substance (Hayes 1991).

<u>Transport, Labelling and Packaging</u>

By the early 1990s, the UK was already signatory to a number of international agreements covering the carriage of chemicals by rail, road, air and sea (Smith and Purdy 1990). Additionally, regulations had been enacted by the Department of Transport covering the carriage of hazardous materials in road tankers and tank containers (Health and Safety Executive 1981); for the classification, packaging and labelling of hazardous materials both in transit and with the purchaser (Health and Safety Executive 1984); and for the carriage of hazardous materials in packages (as distinct from tankers) (Health and Safety Executive 1986).

The main purpose of these regulations was to ensure that, in the event of a transportation-related chemical incident, information on the substances involved would be readily available to the emergency services on their arrival at the scene. This was considered essential in guiding their respective response actions.

Pollution Inspectorates

Other agencies with statutory responsibilities, at this time, in relation to pollution of the environment in Wales included:

(a) Her Majesty's Inspectorate of Pollution, accountable for monitoring all releases to land, water and air from prescribed industrial premises, to ensure compliance with statutory limits;

(b) National Rivers Authority, set up to check and regulate the quality of water courses, and to invoke the necessary remedial actions in the event of a chemical spillage or leakage into a river, ground water source, estuary or bathing water; and

(c) Her Majesty's Coastguard and Marine Pollution Control Unit, responsible for coordinating the response to chemical incidents at sea.

The Health Service

The only legal powers enabling the involvement of health services in Wales in the management of chemical incidents, at this time, were those provided under section 3(1) of the National Health Service Act 1977, which states that:

> ... it is the Secretary of State's duty to provide throughout England and Wales, to such extent as he considers necessary to meet all reasonable requirements:
> (a) hospital accommodation;
> (b) other accommodation for the purpose of any service provided under this Act;
> (c) medical, dental, nursing and ambulance services; ...
> (e) such facilities for the prevention of illness, the care of persons suffering from illness and the after-care of persons who have suffered from illness as he considers are appropriate as part of the health service;
> (f) such other services as are required for the diagnosis and treatment of illness.
>
> (National Health Service Act 1977)

In the early 1990s, these duties were exercised on behalf of the Secretary of State for Wales by 9 District Health Authorities (DHAs) in Wales. The duties relate primarily to medical support and care. However, in attempting to broaden the perspective of DHAs in Wales from purely a therapeutic role at the time of chemical incidents, to a more strategic protection of health role, Welsh Office had followed the lead of the Department of Health, in issuing two circulars. The first (Welsh Health Circular (89)1), issued in 1989, advised DHAs that they were also expected to examine and minimise the risks presented by environmental hazards to the health of people within their respective areas, and to assess any measures needed to improve their health (Welsh Office 1989). The second, Welsh Health Circular (91)65, issued in 1991, had gone even further in requiring DHAs to:

> ... (a) ensure that comprehensive provision exists to safeguard their residents and cover all at-risk installations within their district;
> (b) ensure that all appropriate units and ambulance services have up-to-date, coherent and comprehensive plans for dealing with major incidents.
> (Welsh Office 1991)

Control and Coordination Arrangements

In practice, the initial response to an acute chemical incident in Wales, as is still the position today, was usually provided by the emergency services. Once alerted, one of their first tasks was to consider the control and coordination arrangements that needed to be put into place for the incident. In this respect, dependent on the scale of the incident, the "Senior Police Officer" present was responsible for setting up the appropriate levels of the Strategic (Gold), Tactical (Silver) and Operational (Bronze) command and control structure.

The "Incident Control System" (ICS) in Wales in the early 1990s was therefore based on a classic command and control model of emergency management, which has since been openly criticised (Neal 1995). In particular, Quarantelli surmised in 1991 that:

> ... the recommended shift of command from officers of lower rank to those of higher often leads to loss of information and effective management. The ICS (also) involves primarily *intraorganisational* planning that does not provide for an interfacing or integrating of activities with relevant organisations from outside the (response) community.
> (Quarentelli 1991)

From the author's perspective of working as a district council Environmental Health Officer in Wales from 1988 to 1992, the latter statement was very true. When called to an incident to advise on the environmental health risks to the community, it was very difficult to break in to the rigid structure of the ICS. From direct personal contact with Directors of Public Health (DsPH) and Consultants in Communicable Disease Control (CsCDC) of DHAs in Wales, at this time, the author was also aware that they were very rarely alerted to chemical incidents, and were not seen as part of the broader liaison arrangements of the ICS. This was difficult when such professionals had been assigned particular responsibilities under the afore-mentioned circulars issued by Welsh Office.

Roles and Responsibilities of Response Organisations

It is not intended to provide a line by line account of the roles and responsibilities of the various response organisations, as they was seen in the early 1990s. However, from a review of the literature available at that time, it was evident that the roles perceived of DHAs in Wales were very narrowly defined. For example, in their report to CEC, Smith and Purdy stated of health authorities in the UK that their response to an emergency involved:

> ... local hospitals, doctors and ambulance services.
>
> (Smith and Purdy 1990)

Likewise, in the Home Office publication "Dealing with Disaster", reference was only made to the roles of the ambulance service and the receiving hospitals (Home Office 1992).

Discussion

From the above review of arrangements for the response to chemical incidents in Wales in the early 1990s, two perspectives were evident. Other response organisations, and even "other government departments", perceived the role of DHAs to be limited to that of ensuring the provision of ambulance and hospital services only. In contrast, by issuing the two circulars, Welsh Office (following the lead of the Department of Health) were making a clear statement of intent that they wished to see a broadening and strengthening of the involvement of public health professionals from DHAs in the future management of acute chemical incidents in Wales.

Strengthening the Public Health Role in the Management of Acute Chemical Incidents in Wales

Introduction

The views of Welsh Office, and likewise the Department of Health, were understandable given their experiences in relation to a number of high profile chemical incidents during the 1980s.

In 1984, the River Dee in North Wales was polluted with phenol, with subsequent contamination of the drinking water supply serving approximately two million consumers (Jarvis *et al.* 1985). Despite reassurances from the water authorities that there was no health risk, a retrospective cohort study found that people supplied with contaminated water had experienced significantly more gastrointestinal illness than those in a nearby unexposed area. The River Dee incident was followed in 1985 by the referral of three unrelated children to the same general hospital in Cardiff, Wales over a two-week period, suffering from aplastic anaemia (Morgan *et al.* 1988). Two of the children had bone marrow transplants and the third died. Investigations failed to demonstrate a common environmental toxin. The two incidents raised major concerns for Welsh Office in terms of the lack of arrangements that were found to be in place for the public health management of acute environmental hazards within the principality. In the absence of any other agency, both incidents had been investigated by staff of the Public Health Laboratory Service, whose remit was normally restricted to communicable disease control.

Similarly, in England, much of the Department of Health's concern had arisen as a result of the water contamination incident at Lowermoor, Cornwall in 1988 (Rowland *et al.* 1990). Serious public anxiety about the possible long-term health effects of exposure to aluminium-contaminated water had even prompted the then Parliamentary Under Secretary of State for Health to establish the "Lowermoor Incident Health Advisory Group" (LIHAG), under the chairmanship of Professor Dame Barbara Clayton (Cornwall and Isles of Scilly District Health Authority 1989).

It was therefore desirable for Welsh Office, and also the Department of Health, to be seen as acting responsibly in dealing with these problematic public health issues. As the first principle of national policy was that matters of this nature should be dealt with at the local level, both Departments were able to readily discharge their responsibilities through placing additional roles on DHAs.

The Response of Public Health Professionals

Part of the problem for DHAs was that there was a perceived lack of clarity over which official was responsible within their organisations for the handling of acute chemical incidents. From 1974 to 1988, DHAs had been required to appoint a physician as their Medical Officer on Environmental Health (MOEH) (Hill and O'Sullivan 1992). Employed by the DHA, the MOEH was also designated as the local authority's "Proper Officer" for the control of notifiable diseases and food poisoning. In 1988, however, following a fundamental review of "Public Health in England", the responsibilities of the post of MOEH were split between a newly created post, that of Consultant in Communicable Disease Control (CCDC) (who would fulfil the afore-mentioned "Proper Officer" role), and the existing post of DPH, who was expected to become the focal point for medical advice on environmental health issues generally (Acheson 1988).

The social reforms of 1974 had also, to a large extent, divorced public health doctors in DHAs in Wales from the environmental work carried out by local authority Environmental Health Departments (Forbes 1993; McPherson *et al.* 1998). The Welsh Office, and likewise the Department of Health, were therefore placing responsibilities on DHAs for which they were not best prepared or resourced (Duckworth 1991). This was recognised to some extent by LIHAG, which, in the first of two reports on the Lowermoor incident, recommended that:

> ... an appropriate expert organisation should be designated to provide DsPH with authoritative medical and toxicological advice, without delay, in the event of an incident. A national panel should be established, comprised of independent scientists, whose expertise is most likely to be relevant and who would be willing to assist the designated organisation at short notice.
>
> (Cornwall and Isles of Scilly District Health Authority 1989)

Although welcomed on its introduction in 1991, the remit of the so-called "Health Advisory Group on Chemical Contamination Incidents" (HAGCCI) (access to which was available to the Chief Medical Officer for Wales and the DsPH of Welsh HAs) was initially limited to the provision of advice in the event of serious contamination of a water supply. There was therefore no capability within HAGCCI to deploy a team of experts to the scene of an incident to make an urgent clinical and epidemiological assessment of the health impact (Baxter 1991). Neither did the establishment of HAGCCI obviate the need for the rapid availability of epidemiological, laboratory, and toxicological skills at the local level (Baxter 1990).

Additionally, the deficiencies of training in aspects of environmental health not related to communicable disease, which had been raised following the 1988 publication "Public Health in England" still remained (Baxter 1989; Phillip 1990).

There were also major concerns regarding the ability of the NHS to fulfil those roles and responsibilities which the other response organisations expected them to undertake. In the UK, public health professionals were more used to disaster planning for major trauma than for mass chemical exposures and the medical management problems they posed (Baxter 1991). As a result, the level of preparedness of accident and emergency departments in the United Kingdom was considered to be variable with regards to training, the use of chemical incident protocols, the provision of protective clothing and antidotes, and the availability of facilities for decontaminating seriously ill casualties (Baxter 1991; Thanabalasingham, Beckett and Murray 1991; Cooke 1992; Hunter and Mannion 1992).

A Study of Arrangements for the Identification and Investigation of Incidents of Acute Exposure of the Public to Toxic Substances (Hill and O'Sullivan 1992)

To investigate these concerns further, in March 1991, the NHS Management Executive of the Department of Health established a Steering Group to oversee a study to investigate the size of the problem of incidents of acute exposure of the public to toxic substances in England, and to assess the adequacy of NHS arrangements for the investigation of such incidents (Hill and O'Sullivan 1992). Although based in England, the findings of the study were equally applicable to Wales, as reflected by the fact that Welsh Office soon followed the lead of the Department of Health in responding to many of the conclusions and recommendations drawn. The study involved a postal questionnaire survey of professionals within the NHS (DsPH, Chief Ambulance Officers, Poisons Unit Directors, Consultants in charge of Major Accident and Emergency Departments), as well as local authority Chief Environmental Health Officers. It was therefore not a surveillance study, but a retrospective snapshot of the size of the problem of incidents of acute toxic exposure in England in 1990.

Eighteen per cent of the respondents (response rate: 60%) reported at least one incident, as defined, during the 12-month study period. The large number of incidents reported (N = 843) was, however, somewhat biased by the fact that one respondent (the Director of a Poisons Unit) reported

600 incidents. The most commonly reported incidents were fires (27%), and nearly half (47%) originated in factories or other places of work. In 14 incidents, more than 100 people were reported as having been exposed, although most incidents (75%) resulted in less than 11 people being exposed. More than 30 people became ill in each of 13 separate incidents, and in four incidents, fatalities were recorded.

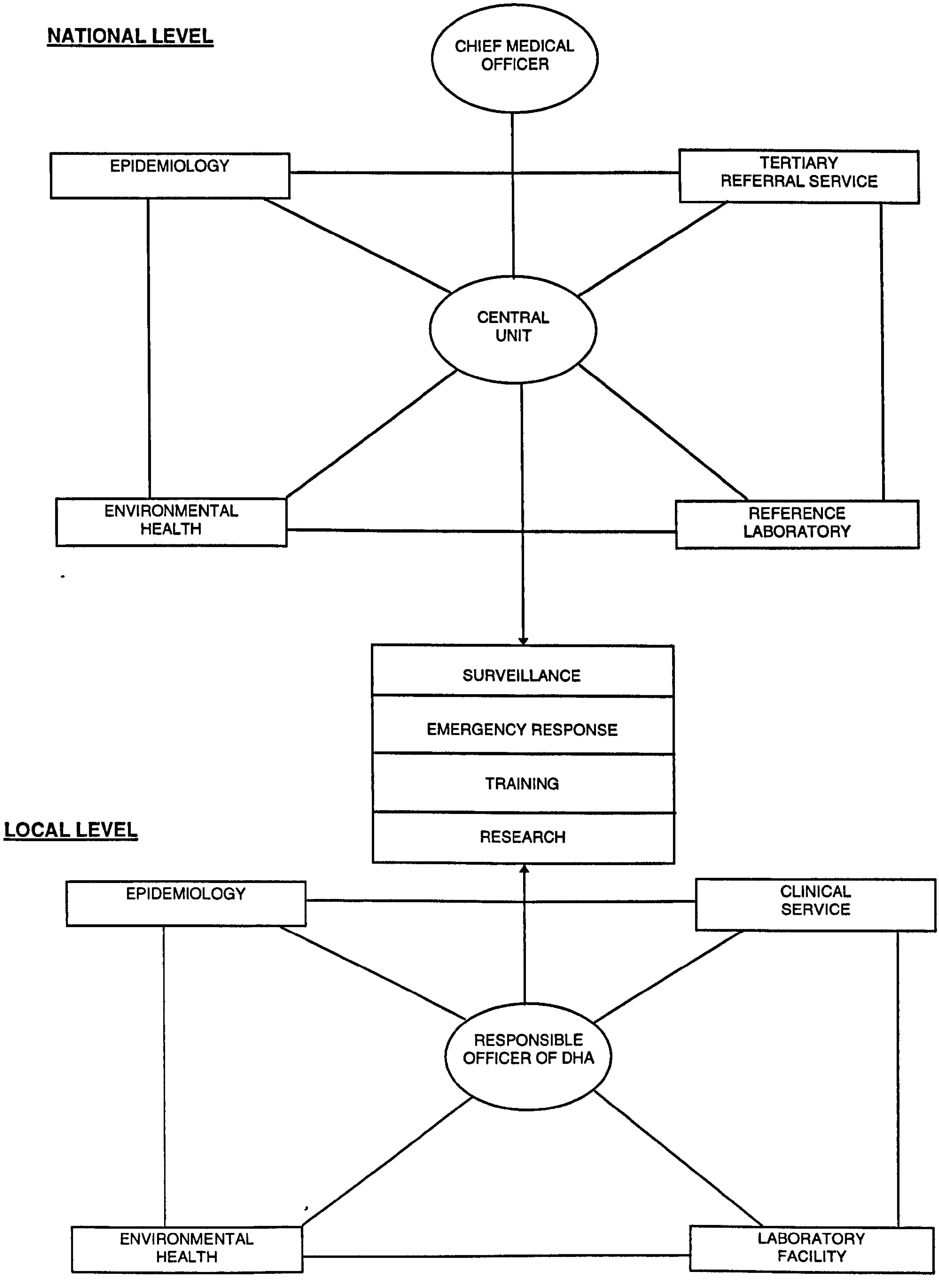
The most pertinent findings from the study, however, were that 24% of the respondents did not actually know what local and national arrangements existed for the investigation of such incidents; and of those who did know, only 25% considered the existing arrangements to be adequate. Sixty-five percent of all respondents either felt that changes were necessary (29%) or stated that they were unsure (36%). A large number of the respondents also made comments in relation to the perceived deficiencies of the existing arrangements, which Hill and O'Sullivan summarised as follows:

> ... the findings suggest that within the NHS, roles and responsibilities, and lines of communication and accountability in the event of an acute toxic incident which could endanger the public health are not clear. In addition, systems for the essential functions of providing advice, assistance and co-ordination are not well established. Implications to be addressed include: clarification of roles and responsibilities, and the provision of a capacity within the service to provide the essential functions of surveillance, emergency response, training and research.
>
> (Hill and O'Sullivan 1992)

The area within the existing arrangements, however, which was highlighted as being the most deficient was the lack of any clear national mechanism for the provision of adequate practical support locally in the toxicological and epidemiological investigation of incidents.

On the basis of these findings, Hill and O'Sullivan developed an idealised model for a national service for the investigation of the health effects of acute environmental incidents, as shown in Figure 4.1. Two levels of operation were proposed, with the health authority acting as the local unit and a new central unit being established at the national level. At each level, the service was seen as comprising of four basic elements: epidemiology, clinical medicine, environmental health and laboratory science. Additionally, the four boxed functions of surveillance, emergency response, training and research were included to represent those elements of the service where co-operation would be required at the interface between the local and national level. This was contrasted with an

Figure 4.1 A model for a national service for the investigation of the health effects of acute environmental incidents



Source: Hill and O'Sullivan 1992

outline of what the authors perceived to be the present arrangements for the investigation of acute incidents of exposure of the public to toxic substances, as shown in Figure 4.2.

In making recommendations for the progression of their idealised model, Hill and Sullivan considered that:

> ... any development should occur within the framework of the National Poisons Information Service (NPIS).
>
> (Hill and O'Sullivan 1992)

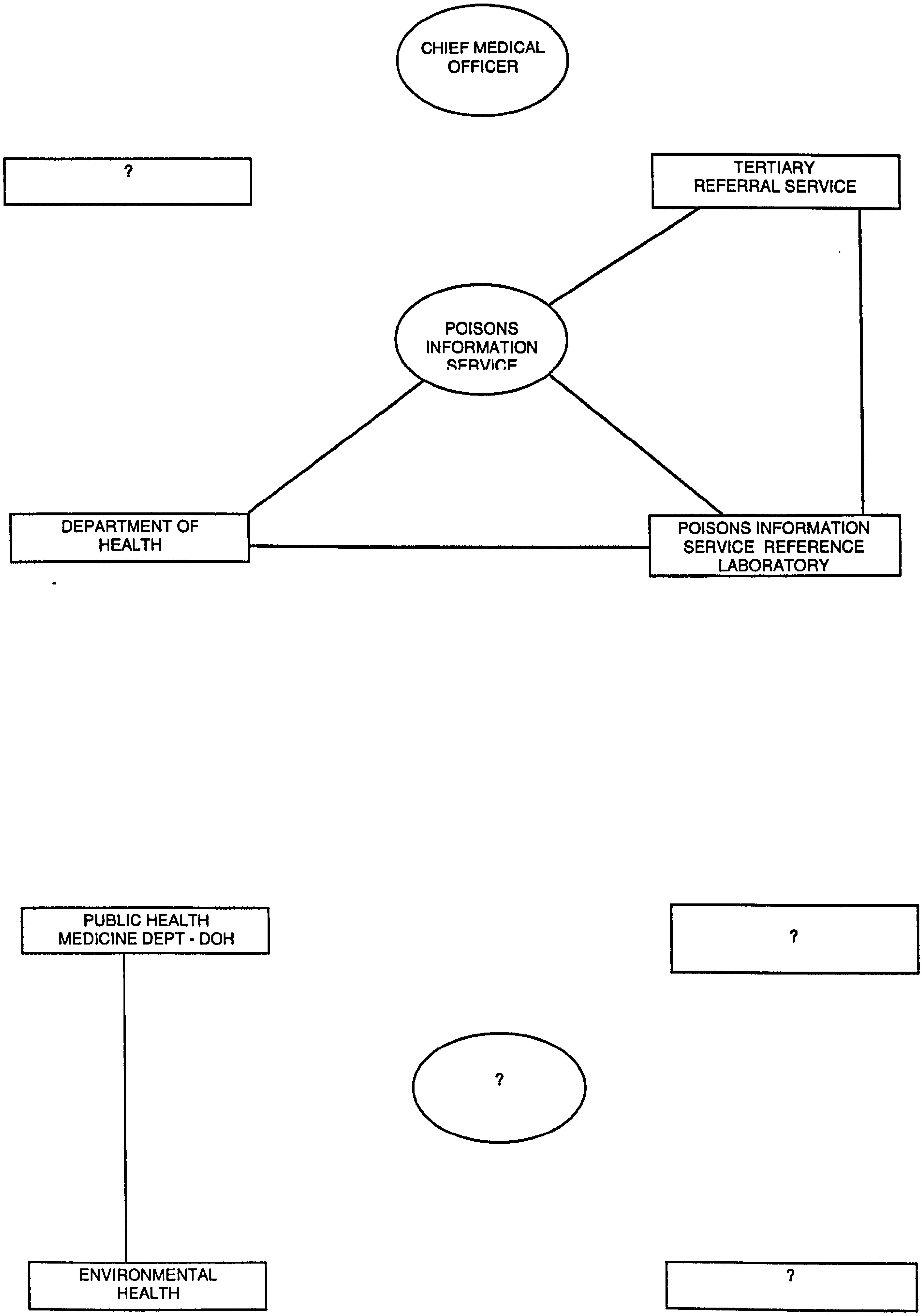
The latter service was established in 1963, as a result of the recommendations of a report to the then Ministry of Health on "Emergency treatment in hospital of cases of acute poisoning" (Ministry of Health 1962). As is the position today, the service for the UK was based around seven centres, namely London, Birmingham, Leeds, Newcastle, Cardiff, Edinburgh and Belfast. The service for Wales was provided by the Welsh National Poisons Unit, based at Llandough Hospital, Cardiff, with funding from Welsh Office (see Chapter 5 for further details of the Unit). In their ability to offer toxicological, laboratory and clinical services, in addition to their core function of providing information, on a 24 hour basis, to health professionals on the medical management of poisoning cases, the NPIS was seen as fulfilling many of the elements of the central unit. Its limitations, however, were stated in terms of only having an *ad hoc* role in the coordination of activity relating to the investigation of incidents, and possessing no formal roles in training and surveillance (Hill and O'Sullivan 1992).

Criticism was also aimed at the Department of Health, regarding the lack of official central guidance, regarding where responsibility should lie within the NHS for the local coordination of investigative services at the time of an incident of acute toxic exposure (Hill and O'Sullivan 1992).

Existing Arrangements for the Public Health Management of Acute Chemical Incidents in Wales

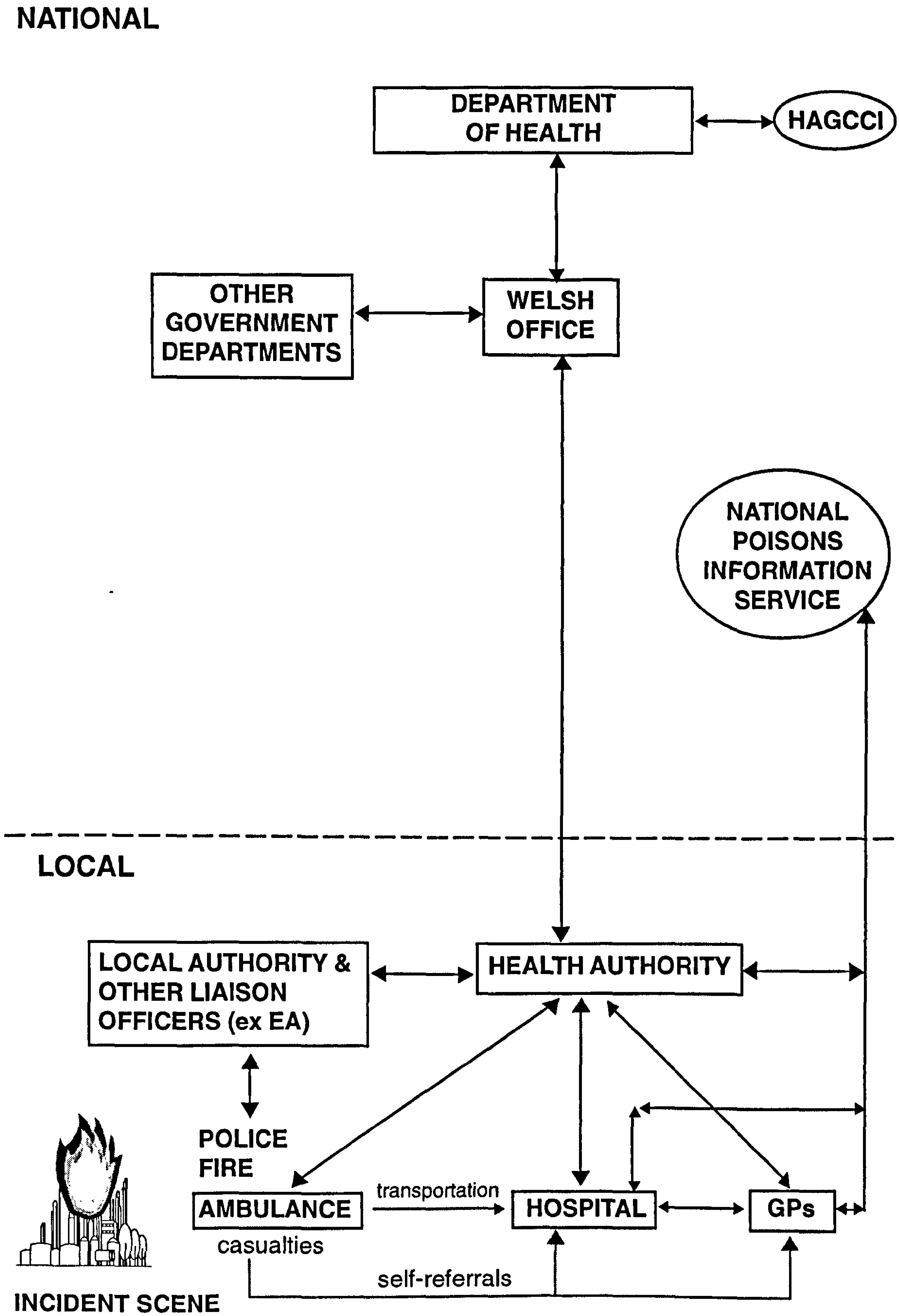
On the basis of the above discussions, Figure 4.3 provides a simple model of the arrangements that the author perceived were in place in Wales in 1992 for the public health management of acute chemical incidents. DHAs had access to two sources of advice: (a) the Welsh National Poisons Unit and (b) the HAGCCI advisory system. However, contact with the latter was only available to DsPH and the Chief Medical Officer for Wales through a secretariat located at the Department of

Figure 4.2 The present arrangements in England for the investigation of the health effects of acute exposure to toxic substances



Source: Hill and O'Sullivan 1992

Figure 4.3 Model of existing arrangements for the management of the health effects of acute chemical incidents in Wales



Health. The model also shows the idealised links that should have been in place at the local level for the effective inter-agency management of an acute chemical incident.

The Introduction of Further Health Service Guidance

In response to the recommendations made by Hill and O'Sullivan, the Department of Health issued two "Health Service Guidelines" in 1993, namely HSG(93)38 (Department of Health 1993a) and HSG(93)56 (Department of Health 1993b). In Wales, these were soon replicated by Welsh Health Circulars WHC(93)61 (Welsh Office 1993) and WHC(94)26 (Welsh Office 1994).

Under WHC(93)61, DHAs were required to have in place adequate plans for dealing with the health aspects of chemical incidents, and to designate an "appropriate officer" to ensure access to the necessary advice and expertise concerning the public health hazards arising from such incidents. Enclosed with WHC (93)61 was further detailed guidance on "Health Service Arrangements for Dealing with Chemical Hazards", which made explicit the specific responsibilities placed on DHAs in Wales for:

> ... the protection of the health of, and provision of health care to those who have been or may be exposed to a chemical hazard.
>
> (Welsh Office 1993)

The later issue of WHC(94)26 served only to reinforce the advice already given, by requiring:

> ... all parts of the NHS to review their arrangements to ensure they are able to discharge their responsibilities for dealing with the health aspects of non-communicable environmental hazards.
>
> (Welsh Office 1994)

The latter guidelines also confirmed the monitoring and surveillance responsibilities of DHAs. These included for:

> ... the continuing surveillance of disease, possible causative factors and influences in the DHAs area to identify and investigate any pattern of disease which is unusual or novel.
>
> (Welsh Office 1994)

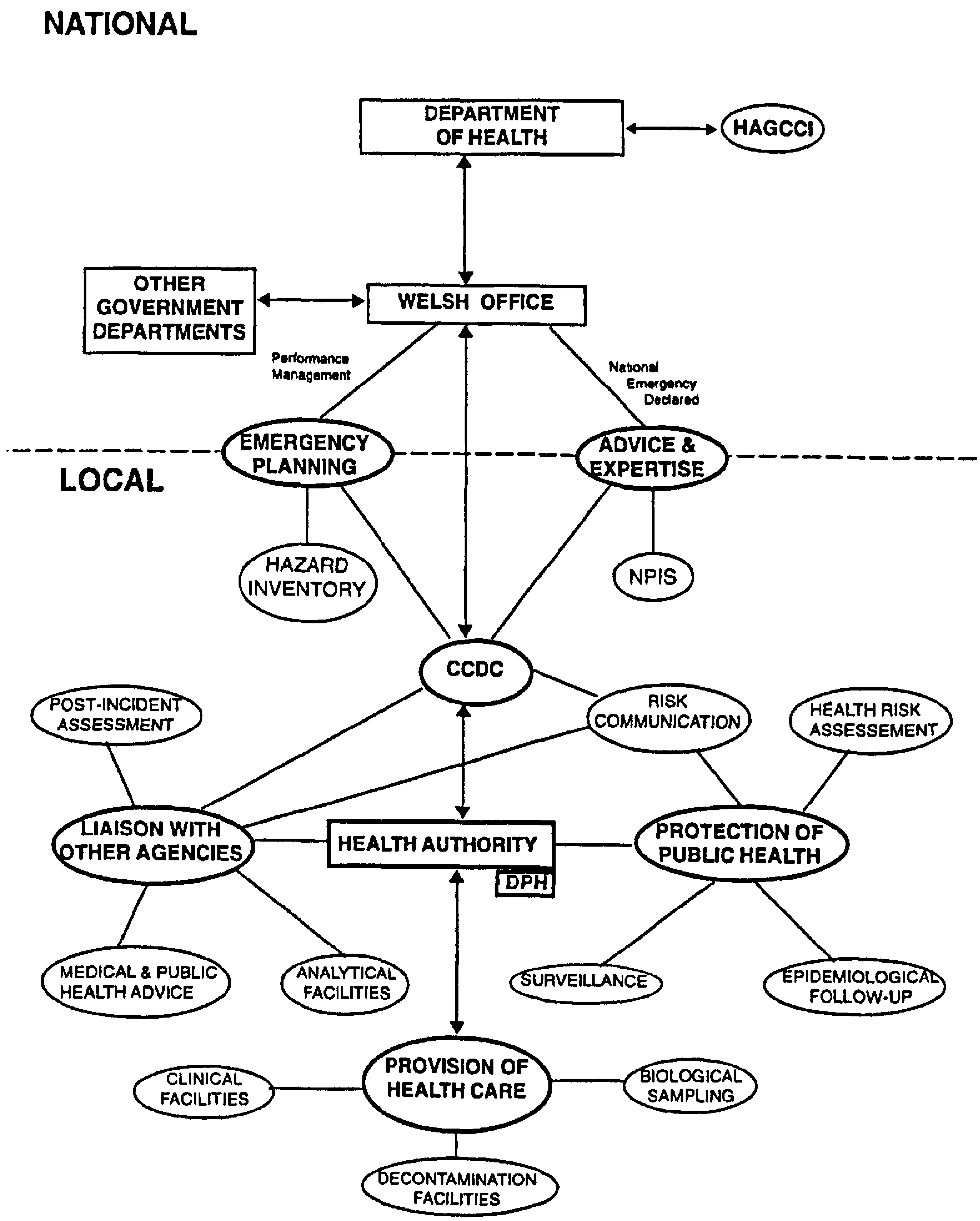
Conclusion

The Department of Health and Welsh Office (in following their lead), had therefore chosen a policy line which was intended to clarify, but which had effectively increased the roles, responsibilities, and accountability of DHAs in England and Wales respectively, in relation to health service arrangements for dealing with acute chemical incidents. The full extent of these responsibilities is demonstrated by the model shown in Figure 4.4.

However, the Welsh Office were still cognisant of the underlying concerns of those public health professionals, that is DsPH and CSCDC, responsible for dealing with these issues at DHA level in Wales. These included questions of additional expertise and resources, expanded training opportunities and consideration of the need for access to advice and support on a 24 hour, 365 day basis, above and beyond that already available from the Welsh National Poisons Unit. They were also keen to see whether the findings of Hill and O'Sullivan's study were replicated in Wales.

Although the circulars were issued shortly after the commencement of the surveillance system in Wales, there was no doubt that Welsh Office were keen to better define the size of the problem of acute chemical incidents within the principality and of the extent of any additional expertise and resources required to support public health professionals in Wales. Hence, the development of the All Wales Environmental Health Surveillance Project for Wales.

Figure 4.4 Model of Health Service Arrangements for Dealing with Chemical Incidents, in Wales in compliance with WHC(93)61



Chapter 5 - All Wales Environmental Health Surveillance Project

Introduction

In this Chapter, the author will describe the conduct of an unique, collaborative project involving the surveillance of acute chemical incidents in Wales from 1993 to 1995. The All Wales Environmental Health Surveillance Project (AWEHSP) brought together central government, local government and academics with the common goals of better defining the size of the problem of acute chemical incidents within the principality, and of identifying the additional expertise and advice needed to support health and environment professionals in the management of such incidents. The AWEHSP was important as a surveillance project in its own right. However, in the context of this thesis, it is used as the basis for the development of the public health management model.

Objectives

As described in Chapter 3, remarkably little formal documentation of acute chemical incidents has taken place anywhere in the world, let alone in Wales. To identify the specific needs of public health professionals within the principality, baseline data was therefore required in order to better define the size and nature of the problem, as well as the expertise and resources essential for the effective management of such incidents. The project had four objectives:

Objective 1: To describe the range, frequency and distribution of acute chemical incidents in Wales;

Objective 2: To describe the morbidity and mortality of employees, emergency services personnel and the general public exposed to acute chemical incidents in Wales;

Objective 3: To identify what additional expertise, if any, is required for the successful management of acute chemical incidents in Wales; and

Objective 4: To recommend how such expertise might best be provided in Wales.

Organisation of the AWEHSP

In line with the theory of model development, a multi-disciplinary, multi-agency approach was followed involving Welsh Office, the Council of Welsh Districts (now the Welsh Local Government Association), Cardiff Institute of Higher Education (now the University of Wales Institute, Cardiff) and the Public Health Laboratory Service. To secure the commitment of participants, funding was sought on a joint basis, with 50% of the annual costs being met by Welsh Office (through the Chief Medical Officer's Research Budget in years 1 and 2, and Environment Division in year 3), and the remainder through contributions of £600 per annum from local authority Environmental Health Departments in Wales (co-ordinated through the Council of Welsh Districts). The author was employed by Cardiff Institute of Higher Education, which also provided the necessary project support infrastructure.

At an early stage, a Steering Group was formed to oversee the work undertaken on the project. Representatives were sought from organisations in Wales, whose support and interest in the project were seen as essential to its success. Accordingly, they were drawn from medical, public health, environmental health, administrative and policy backgrounds. The group met on twelve occasions during the three years of the project and proved invaluable in developing the surveillance system. In particular, each member was able to advise on the priorities and methods that they considered consistent with the needs and resources of their respective organisations. A full list of members is provided at Appendix 5.1.

Method

Thacker *et al.* stated that any public health surveillance system must fulfil three functions:

(a) enable the measurement of specific hazards, exposures and health outcomes;
(b) produce an ongoing data record; and,
(c) generate timely and representative data that can be used for planning, implementing and evaluating public health activities.

(Thacker *et al.* 1996)

An organised approach to planning, developing, implementing, and maintaining the surveillance system was therefore recognised as essential (Teutsch 1992). Accordingly, the steps shown in

Table 5.1 were followed in the planning of the surveillance system. At the outset, careful consideration was also given to the attributes that would eventually be used in the evaluation of the system. Above all, the system needed to be feasible and acceptable to those involved, but sensitive enough to provide the information required in a timely manner, without exceeding the budget allocated for the project.

Table 5.1 Steps in Planning a Surveillance System

1.	Establish Objectives
2.	Develop case definitions
3.	Determine data source or data-collection mechanism (type of system)
4.	Develop data-collection instruments
5.	Field-test methods
6.	Develop and test analytic approach
7.	Develop dissemination mechanism
8.	Assure use of analysis and interpretation
Source:	Teutsch (1992)

As the project was time limited, the Steering Group considered it important to provide some focus to the surveillance activities. The project was therefore separated into three phases. Within each phase, targets were then set, together with implementation dates.

Phase 1 of the Project - Target A

Responsibility for identifying health problems arising from acute chemical incidents and taking action to prevent, remove or mitigate them lies with many different agencies in Wales (as described in Chapter 4). However, local authority Environmental Health Departments were perceived as having a central and vital role. They are often the first contact points for the public, should there be any concern regarding the possible health effects of having been exposed to an incident. **The first target for Phase 1 of the project was therefore to design, develop and implement a confidential reporting system with the Environmental Health Departments of the then thirty-seven district councils and two port health authorities in Wales**

(subsequently amalgamated in April 1996 to form 22 new unitary authorities). A target date of 1 January 1993 was set for implementation of the reporting system.

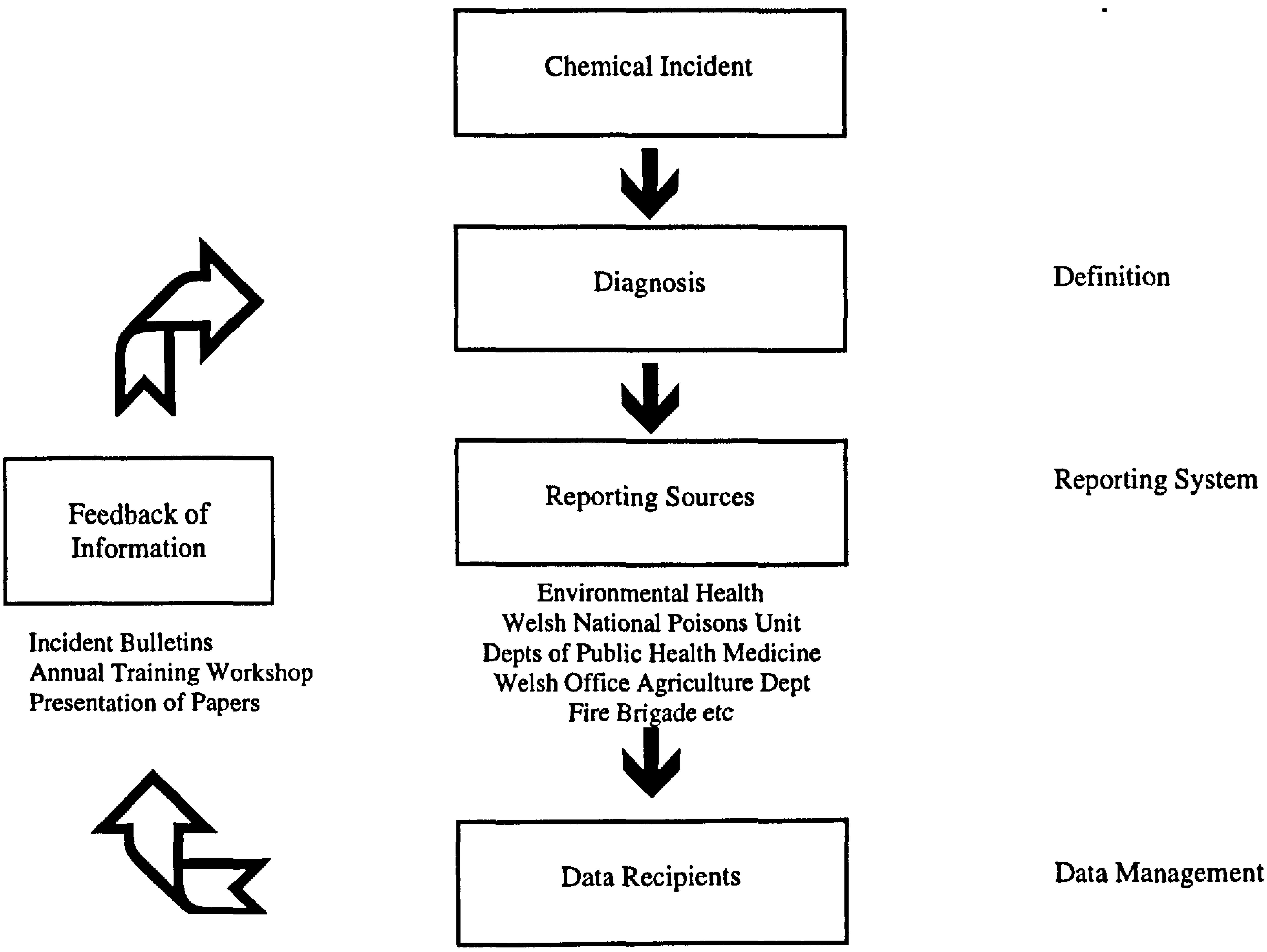
The Surveillance System

Figure 5.1 provides a simple schematic of the surveillance system developed. On becoming aware of an incident, the first decision to be taken was whether it met the case definition.

Definition of an Incident

Following discussions with officers of a number of local authority Environmental Health Departments in Wales and peer review by the Steering Group, it was agreed to use the following definition of an incident:

Figure 5.1 The Surveillance System



Definition of an Incident

any unforeseen event which causes ill-health or which has the potential to cause ill-health and which necessitates an immediate response

or

one or more individuals suffering from an illness which might be due to such an event

The definition was intended to embrace both types of public health environmental problems recognised by the World Health Organisation: those arising because of potential exposure situations and those coming to attention because of concern about illness events (World Health Organisation 1991). The most important part of the definition, however, was the wording "and which necessitates an immediate response". This precluded problems of a long-standing and unresolved nature and focused attention on acute incidents.

Interpretation was further assisted by the production of a list of examples of the types of incidents that met with the definition and also of those that did not require reporting. Included were explosions, fires, airborne releases, chemical spills, and contamination of food, soil and water, as well as incidents of illness in individuals or populations attributed to such an event, but where neither an event nor a substance had been identified. Excluded were events of exposure or illness related to infectious diseases and radioactive materials, as were routine industrial emissions subject to process regulations.

A System of Reporting

Primary surveillance systems are traditionally classified as passive or active (Mausner and Kramer 1985). For example, most routine notifiable-disease surveillance systems rely on passive reporting, that is, the local health authority receives disease reports from various health care providers on a case-by-case basis. In contrast, an active surveillance system is one where regular contact is made with data providers to elicit reports, including nil returns. In view of the criticisms commonly aimed at passive systems of variability and incompleteness in reporting (Sullivan, Gibbs and Knowles 1992; Teutsch 1992), an active system of surveillance was selected for the project.

A system of monthly reporting was agreed with the local authority Environmental Health Departments and, accordingly, prompts issued by the author during the first week of each new month, requesting that either an incident report(s) or a "nil return" be submitted for the previous month. Initially, it had been planned to take advantage of new technology for information collection and dissemination, that is, the Epinet communications system. However, it soon became apparent that this would involve additional resources, in terms of training Environmental Health Officers in the use of the system, which was outwith the scope of the project.

Although each local authority Environmental Health Department nominated reporting officers for the completion of returns, the monthly prompts were always issued via a letter addressed to the Chief Environmental Health Officer. The intention was to make the latter accountable for ensuring that their reporting officers sent in reports of incidents or 'nil returns'. This subsequently proved very effective, as highlighted by the excellent response rate achieved (see Results). Of particular importance in securing the co-operation of local authority Environmental Health Departments was the assurance given that the surveillance data would be treated in confidence.

Reporting Forms

A questionnaire was required that would: (a) provide the information needed to meet the objectives of the project; (b) be acceptable to the proposed participants; and (c) facilitate the evaluation and interpretation stage (Bell 1993). As Oppenheim states:

> ... this means, first of all, that the focus and contents of the questions must be right; second, that the wording must be suitable; and third, that the context, sequence and response categories must help the respondent without unintentionally biasing the answers.
>
> (Oppenheim 1992)

The months of November and December 1992 were therefore spent in planning and designing the questionnaire, in consultation with members of the Steering Group. The first stage was to develop a complete specification of the variables that would need to be measured. In this respect, the variables were initially separated into three sections: (a) incident details; (b) actions taken; and (c) lessons learned. As the data normally collected in relation to acute chemical incidents was found to focus mainly on the release of hazardous substances into, and the effects of these releases, on the environment as end-points (Agency for Toxic Substances and Disease Registry 1993), variables were especially included to investigate the many risk factors associated with the morbidity and mortality resulting from such releases.

At the outset of the AWEHSP, three main areas were also identified where it was anticipated that additional support services may be required for the management of acute chemical incidents in Wales. These were:

(a) technical advice and support for measuring toxic chemicals in the environment;

(b) medical advice on symptoms of disease, how to recognise them and how to treat them; and

(c) epidemiological advice and assistance on how to investigate and assess short and long-term risks to health.

Variables were therefore included to identify what expertise (technical, scientific, medical, toxicological or epidemiological) was required by local authority Environmental Health Departments in relation to specific incidents, whether that advice was available and the source used.

Having defined the variables to be measured, the next stage was to develop a series of question modules, each concerned with a different variable, and to consider the order in which they should appear in the final questionnaire. Within each module, question design and wording was carried out in accordance with a short set of simple rules and principles, developed by Oppenheim (1992). The majority of the questions asked were closed, with respondents being asked to tick one or more boxes in relation to a choice of alternative replies. The time for completion of the questionnaire was therefore anticipated to be no more than 30 minutes. Some open questions were however included, allowing respondents to express spontaneity in their views on the handling of specific incidents.

In the design stage, thought was also given as to how to engender and maintain the co-operation of respondents. Questions were therefore included to enable, wherever possible, the use of information held within existing administrative systems. Consideration was also given to the layout, spacing and answering instructions. An innovative technique was to print the questionnaires on differently coloured paper each month, so that they would be clearly discernible amongst the plethora of white papers routinely present on the desks of the nominated reporting officers. Each question also had a covert function: to motivate the respondent to continue to co-operate.

The net result was the development of two reporting forms (see Appendix 5.2). The first served as a summary sheet of incidents for the month in question. If there were no incidents to report, the form was also used to record a "nil return". The second form, the design of which has been described above, was used to gather more detailed information with respect to each incident and was arranged in the format of "Twenty Questions regarding the Incident".

Field Testing

The surveillance system, as detailed above, commenced on the target date set of 1 January 1993. For the first six months, however, the system and, in particular, the data collection instruments were subject to a period of field-testing. This was undertaken with all participating Environmental Health Departments, primarily to assess the feasibility and acceptability of the system, and to detect any difficulties with the content of specific questions. The results were discussed by the Steering Group, at the first and second of its quarterly meetings in 1993, and also by the All Wales Chief Environmental Health Officers Panel (AWCEHOP)[1]. No problems were identified in respect of the system of reporting developed, nor the reporting forms. However, as had been anticipated, there were difficulties relating to the interpretation of the definition of an incident. Accordingly, as a condition to the full implementation of the system, it was agreed that the author should visit and meet with the reporting officers of each participating Department, to provide a harmonised view of the types of incidents that should and should not be reported.

Phase 1 of the Project - Target B

From the perspective of the participating Environmental Health Departments, there was little point in them reporting incidents, if they did not, in turn, benefit from the system. To this end, **a target was set to analyse the data received and produce regular surveillance reports to the Steering Group for subsequent distribution, in confidence, to Chief Environmental Health Officers in Wales.**

[1] The All Wales Chief Environmental Health Officers Panel comprised of representation of the Chief Environmental Health Officers of all 37 district councils and 2 port health authorities in Wales. Meetings of the Panel were held every two months.

Data Management

With any surveillance system, procedures need to be established for the maintenance and retention of paper-based reporting forms, and for entry of the data into computerised databases (Sullivan, Gibbs and Knowles 1992).

On receipt, each incident report was assessed by the author for timeliness, completeness and inconsistencies in the data. Often, a follow-up call was made to the reporting officer to check the accuracy of the data provided. For consistency in data collection and ease of analysis, the AWEHSP followed the lead of the ATSDR (with respect to the HSEESS) by emulating the data collection form in the statistical software package, SPSS for Windows V6. Following assessment, the data was therefore entered, in accordance with an established monthly schedule, into the database. The latter was also quality checked on a quarterly basis to remove any discrepancies from the dataset. The information provided in relation to open questions was not computerised, but retained in the filed paper copy. To guarantee the confidentiality on which the system was founded, access to the database was limited through the use of passwords and the original incident report forms filed and stored in a locked cabinet. Back-up copies of the database were also kept off-site to ensure the integrity of the system in the event of unforeseen problems, such as computer theft, fire etc..

Data Analysis

The database not only provided a repository for data on the incidents reported, but also enabled improved data analysis. The results of these analyses are provided in the next two sections of this Chapter. In the first section, analyses are mainly limited to frequency distributions and cross-tabulations of specific variables in the process of defining the size and nature of the problem in Wales; whilst the second section provides an evaluation of the lessons learned by local authority Environmental Health Departments in the management of such incidents.

Disseminating Information

The standard definition of public health surveillance, included in Chapter 3, requires the timely dissemination of findings to both the providers of data and public health policy makers. As Goodman, Remington and Howard state:

> ... effective communication of public health surveillance results represents the critical link in the translation of scientific information into public health practice.
>
> (Goodman, Remington and Howard 1992)

"Incident Bulletins" were therefore issued on a quarterly basis to the local authority Environmental Health Departments. Included were standard tabular and graphical analyses based on the combined data from all participating Departments, together with narrative reports about incidents of interest. Such feedback was perceived as essential in demonstrating to those involved that their data was being gainfully employed.

The communication of surveillance results generally was, however, facilitated by the fact that all the primary target audiences were represented on the Steering Group. Other channels used included the presentation of update reports at bi-annual meetings of the Welsh Office with Chief Environmental Health Officers in Wales, the publication of an annual report by the Steering Group, and the extensive use of public forums, such as conferences and meetings. An annual one-day workshop for reporting officers from the Environmental Health Departments was also held to review examples of the incidents reported, and to provide an opportunity for feedback and discussion on the effectiveness or otherwise of the reporting system developed.

Phase 2 of the Project - Target A

As stated above, local authority Environmental Health Departments are just one of many agencies in Wales with responsibilities for identifying and reacting to potential health problems arising from community exposures to acute chemical incidents. **The first target for Phase 2 of the project was therefore to identify other sources of data on incidents, and to evaluate the feasibility of including other agencies within the surveillance system. A target date of 1 July 1993 was set for implementation of this phase of the project.**

Health Authorities

The professionals most likely to receive reports where one or more individuals are suffering from symptoms which may be due to a chemical incident, that is, the second arm of the definition, were considered to be the Consultants in Communicable Disease Control (CsCDC) of the then nine HAs in Wales (subsequently amalgamated in April 1996 to form five new authorities).

Following discussions with the All Wales CsCDC Group, it was decided that the most appropriate involvement for CsCDC would be for them to make known any incidents that they became aware of, via the reporting officers of the local authority Environmental Health Departments. This would also have the additional benefit of extending the already well established liaison arrangements between CsCDC and EHOs beyond communicable disease control to acute chemical incidents. This arrangement came into effect on 1 May 1993.

Welsh Water

In March 1993, the author met with the Divisional Manager of Welsh Water to discuss the feasibility of developing a separate, but complementary system for the surveillance of incidents of chemical contamination of water supplies in Wales. However, whilst supportive of the project, Welsh Water considered this to be a duplication of effort, given their statutory responsibilities to notify local authority Environmental Health Departments of all significant incidents involving public water supplies (Water Quality (Water Supply) Regulations 1989). It was therefore anticipated that reports of water contamination incidents would be received via the system already established with local authority Environmental Health Departments.

Welsh National Poisons Unit

In January 1994, however, a separate reporting system was established with the Welsh National Poisons Unit, based at Llandough Hospital, near Cardiff. Established in 1963, as part of the NPIS, the Unit was viewed as representing the first point of contact for Accident and Emergency consultants, other clinicians and CsCDC where specialist toxicological advice was required in respect of the diagnosis, treatment and management of people poisoned (or suspected of being poisoned) by a wide range of substances or products. Although 80 per cent of the enquiries received by the Unit in 1993 related to the accidental or deliberate ingestion of drugs or household products by children or adults, the Unit was receiving an increasing number of calls relating to occupational and population exposures to chemical incidents (Welsh National Poisons Unit 1994).

As the geographical remit of the Unit covered the whole of Wales, it was considered to be an excellent opportunity to evaluate the extent of overlap in the incidents reported by both local authority Environmental Health Departments and the Unit. The only difficulty was that, due to the large number of enquiries handled by the Unit, information on any chemical incident would need to be recorded in real-time. Accordingly, the second of the two reporting forms developed for the local authority system was condensed into a single A4 sheet (Appendix 5.3). Otherwise, the systems of reporting were identical in all respects.

Gwent Fire Brigade

In June 1994, a retrospective study was undertaken with Gwent Fire Brigade, one of the then eight Brigades in Wales (subsequently amalgamated in April 1996 to form three new Brigades), of all acute chemical incidents handled by fire fighters during the period 1 January 1993 to 31 May 1994. A total of 170 incidents were initially identified, although many of these were later excluded when fuller details became available, on the basis of their not meeting the definition.

As only two of the incidents had previously been recorded by those local authority Environmental Health Departments providing services within the same locality, it was decided to develop a pilot reporting system with Gwent Fire Brigade, effective from 1 January 1995. The system of reporting adopted by the Brigade was the same as that developed with the local authority Environmental Health Departments. In this respect, the author provided training and education to each of the Brigade's Station Officers in the interpretation of the definition of an incident, and in the completion of the reporting forms. At the end of each month, reports of incidents or "nil returns" from each station were centrally collated at the Brigade's headquarters, and then forwarded to Cardiff, on receipt of the monthly prompt from the author. The Brigade was also represented on the Project Steering Group (Appendix 5.1).

Other Fire Brigades in Wales

In addition to participating in the project, the Chief Fire Officer for Gwent Fire Brigade also agreed to facilitate its possible extension to other Brigades in Wales during 1995. In this respect, papers were prepared and tabled at a meeting of the Chief and Assistant Chief Fire Officers Association for Wales. However, whilst the proposals received general assent, any further progress was curtailed by the impending re-organisation of the Fire Service in Wales in April 1996.

Police Constabularies

Negotiations also took place during the early part of 1994 with all four Police Constabularies in Wales, regarding the possibility of establishing complementary reporting systems. However, a stumbling block soon became apparent. Details of all incidents investigated by the police were recorded on standard crime record sheets, access to which would not be available to the project, on grounds of confidentiality. The development of reporting systems with Police Constabularies in Wales was therefore not pursued any further.

Health and Safety Executive / Her Majesty's Inspectorate of Pollution

Similar problems over confidentiality of information were experienced with respect to the Health and Safety Executive and Her Majesty's Inspectorate of Pollution, primarily because of their statutory responsibilities in relation to prescribed industrial processes. Approaches were made to both organisations in 1994.

National Rivers Authority

Given the concerns about confidentiality expressed by the Health and Safety Executive and Her Majesty's Inspectorate of Pollution, it was perhaps surprising when the National Rivers Authority (NRA) - Welsh Region agreed to send reports of incidents to the project. The latter were to be limited to all Category 1A incidents, that is, those events categorised as major incidents by the NRA (27 Category 1A incidents occurred in Wales in 1993). It was also proposed to grant the author access to the Authority's central database in Cardiff to extract information on Category 1B (major hazards to water quality) and 2A (significant pollution) incidents, both prospectively and retrospectively back to 1 January 1993. Unfortunately, as the negotiations were being completed, funding for the AWEHSP was coming to an end and it was not possible to operationalise the system that had been developed.

Welsh Office Agriculture Department

The Welsh Office Agriculture Department (WOAD) is responsible for coordinating the Ministry of Agriculture, Fisheries and Food's response in Wales to any chemical incident which may pose a threat to the safety of food or the food chain. Most incidents are handled quickly and effectively by voluntary action, for example, by farmers withholding suspect milk from supply where livestock has been given contaminated feed. However, in the event of a serious incident, WOAD has recourse to wide-ranging powers under Part 1 of the Food and Environmental Protection Act 1985, to prohibit the distribution of affected produce from areas where foodstuffs may have been contaminated, for example, by smoke toxins arising from a chemical fire.

For each of the three years of the project, WOAD provided a simple line-listing of such events, further highlighting the breadth of agencies / authorities in Wales involved in the management of acute chemical incidents.

Phase 2 of the Project - Target B

The second target for Phase 2 of the project was to establish systems for the routine monitoring of national and local newspapers in Wales for reports of acute chemical incidents. This started on 1 January 1993, in advance of the **target date set of 1 July 1993.**

In effect, the only newspapers that were systematically surveyed for the three years of the project were the two nationals in Wales, that is, "The Western Mail" and the "Liverpool Daily Post". The routine vigilance of local newspapers in Wales proved too problematic, given the sheer numbers published and the time it was taking the author to survey them on a weekly basis. The feasibility of a press cutting service was investigated, but the costs were prohibitive.

The primary purpose of such vigilance was to check the sensitivity of the surveillance systems developed with the other agencies/authorities. Where an incident meeting the definition was identified in the press, a copy was taken, and the source and date recorded. If after two months, no report of the incident had been received from the local authority Environmental Health Department within whose area it had occurred, a letter was sent to the Chief Environmental Health Officer enclosing a copy of the cutting. The letter asked if the Officer's Department were aware of the incident and, if so, a request made for them to complete the necessary reporting forms. Similar systems of follow-up were established with the Welsh National Poisons Unit and Gwent Fire Brigade, but by a telephone call to the relevant officers, rather than by letter.

Phase 3 of the Project

The target for Phase 3 of the project was to evaluate the expertise (technical, scientific, medical, toxicological or epidemiological) **currently available within Wales for supporting the handling of acute chemical incidents, and to recommend what additional expertise was required to better support the effective investigation and management of future incidents within the principality.**

The first part of the target was achieved through analysing the responses received in relation to those variables which had been specifically included within the questionnaire to ascertain the nature of expert advice sought (technical, scientific, medical, toxicological or epidemiological) by local authority Environmental Health Departments in handling acute chemical incidents, whether that advice was available and from what source. On completion, the gaps identified were then evaluated in conjunction with the answers provided to the twentieth and final question, that is, the lessons learned, leading to the development of appropriate recommendations on the nature of any additional expertise required to support the effective investigation and management of future incidents within the principality.

Although these processes of analysis and evaluation were ongoing from the start of the project, it was obviously not possible to finalise the recommendations until all the data had been received, that is, after 31 December 1995.

Results

The AWEHSP operated in Wales from 1 January 1993 to 31 December 1995. A total of 642 acute chemical incidents were reported from all sources. The systems developed with local authority Environmental Health Departments and for press vigilance functioned concurrently for the duration of the project. However, those implemented with the Welsh National Poisons Unit and Gwent Fire Brigade operated over different time scales. The results presented below are therefore based on analyses conducted of the combined data sets for each individual reporting source.

Local Authority Environmental Health Departments

Response Rate

A 100 per cent response rate, that is, a nil return or report of an incident, was achieved each and every month for the three year duration of the project.

The Number of Incidents

A total of 270 acute chemical incidents were reported (Figure 5.2). Although there was no seasonal pattern to the reporting of incidents generally, there were underlying peaks in the reporting of specific types of incidents, for example, the proliferation of algal blooms affecting coastal and recreational waters during the summer months. Thirty-six of the 39 Departments handled at least one incident within their respective areas during the three year period of surveillance. The majority (78%) reported less than ten incidents; only 4 reported more than 20 incidents (Figure 5.3). Nearly two-fifths (39%) of the incidents reported came to light as a result of complaints made by members of the public (see Figure 5.4). A further thirty (10%) were identified through the routine district inspection and/or environmental monitoring activities of Environmental Health Departments. The other principal sources of notification of incidents to Environmental Health Departments were the Fire Service (11%), National Rivers Authority (now part of the Environment Agency) (10%) and the operators of the premises where incidents had occurred (9%).

Figure 5.2 **Number of Incidents Reported by Local Authority Environmental Health Departments, Wales, 1993 -1995**

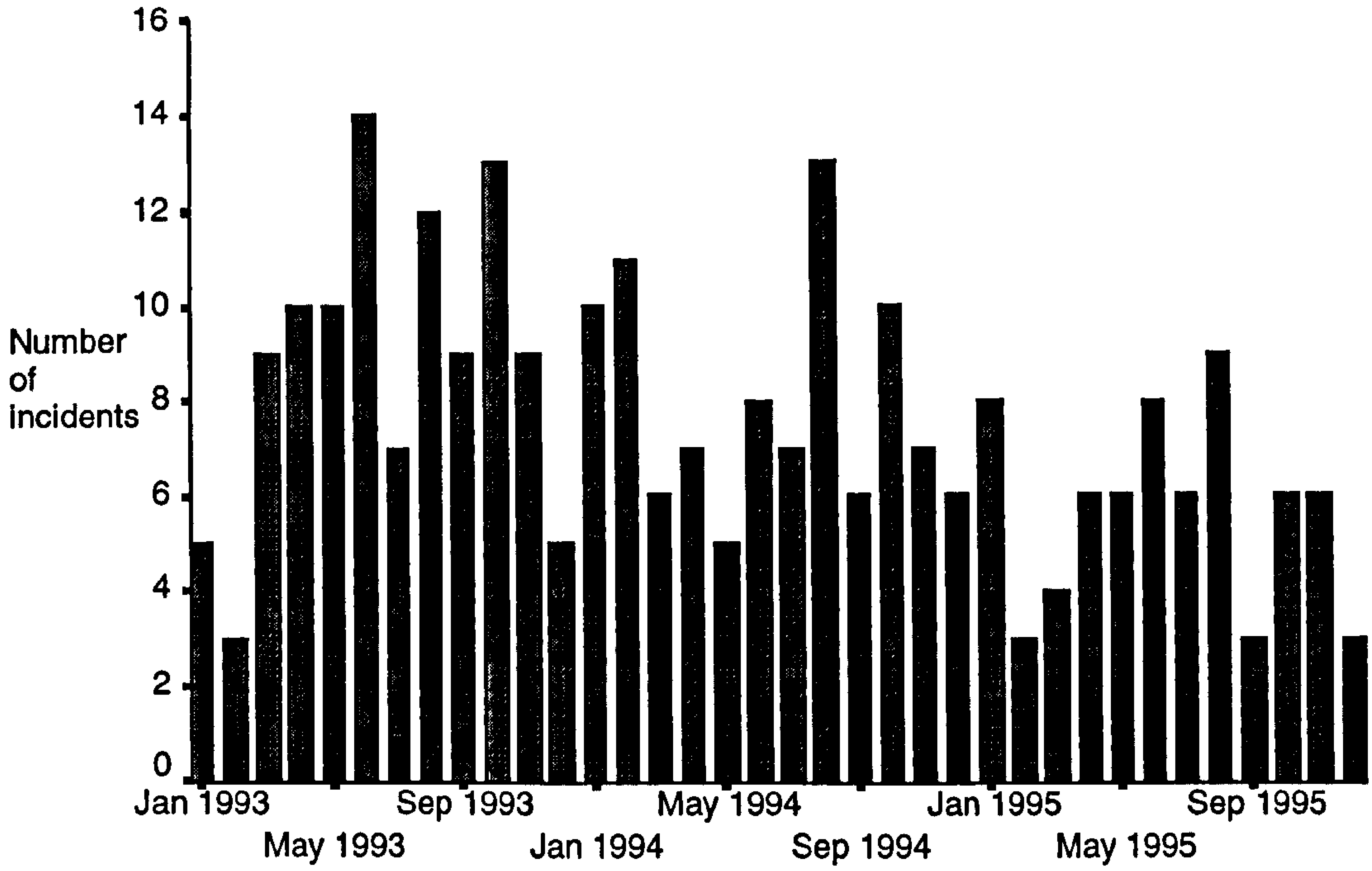


Figure 5.3 **Number of Incidents Reported per Local Authority Environmental Health Department, Wales, 1993 - 1995**

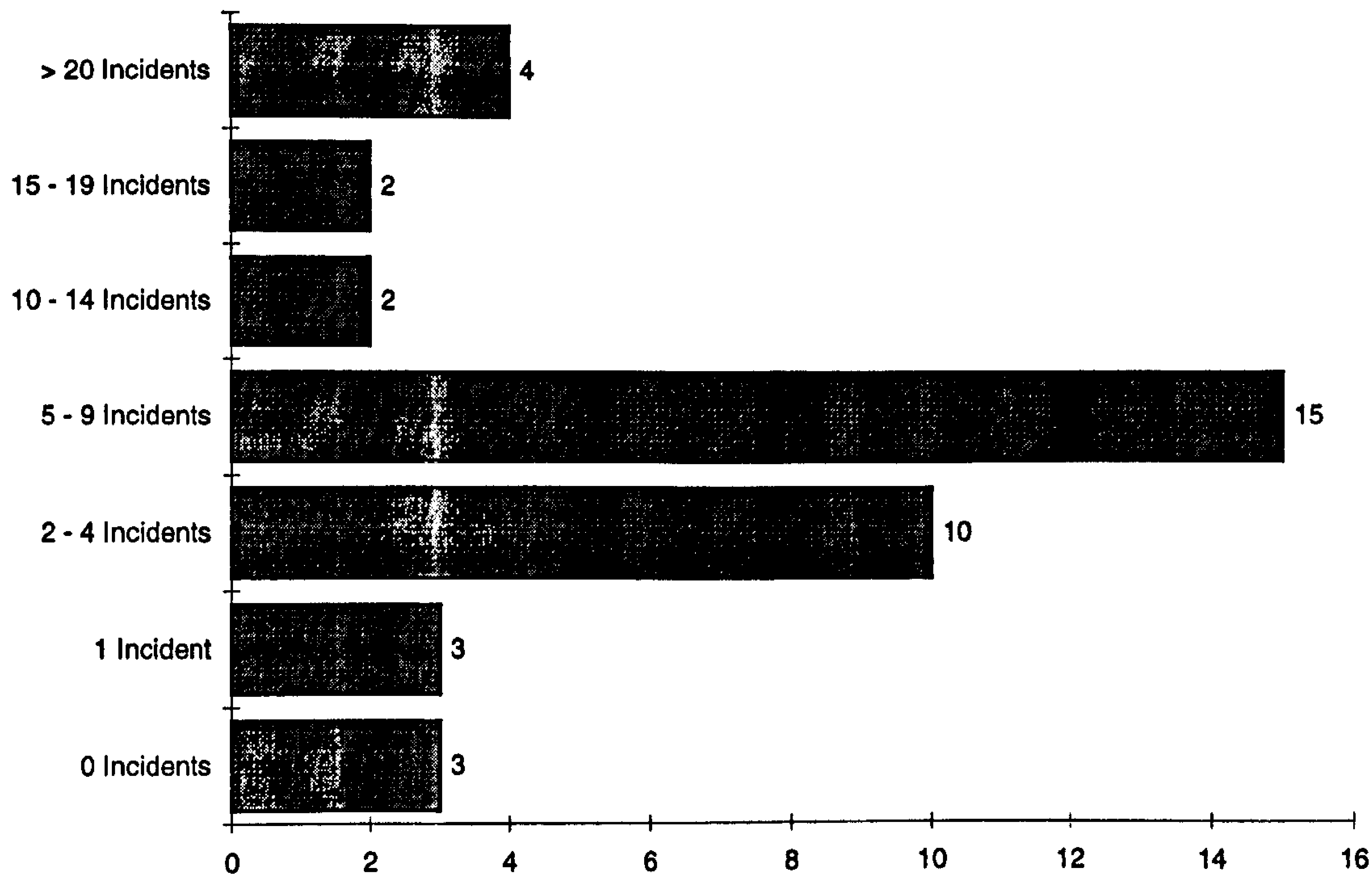
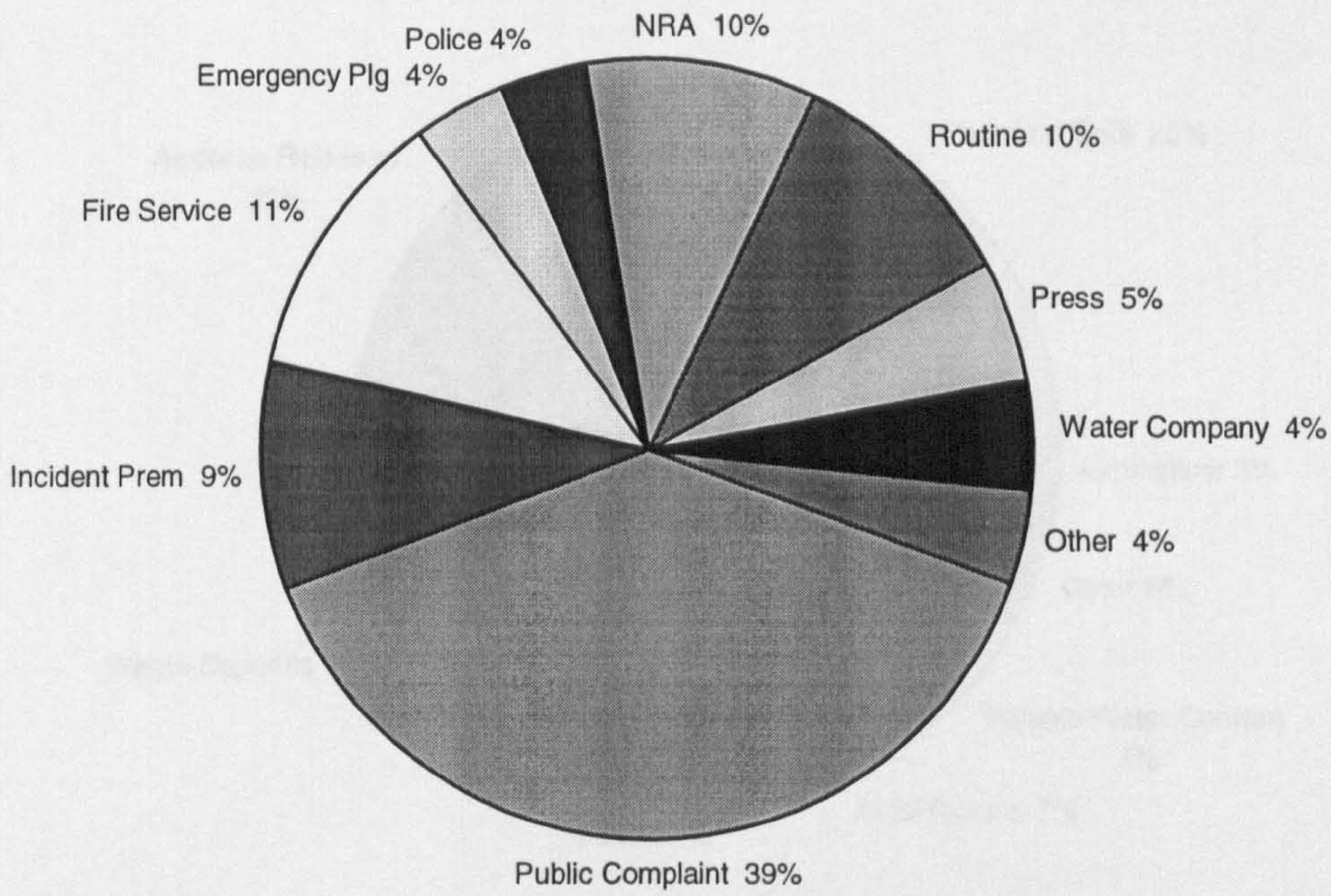


Figure 5.4 Original Sources of Information on Incidents Reported to Local Authority Environmental Health Departments, Wales, 1993 -1995



The Nature of Incidents

For the first time, it has been possible to gain an impression of the nature of acute chemical incidents occurring across Wales. Figure 5.5 shows that chemical spills were the most frequently reported type of incident (28%), followed by airborne releases (22%), and exposures to deposits of waste materials (16%). The remainder included fires (11%), algal blooms (7%) and water contamination incidents (7%).

The Location of Incidents

Sixty-five per cent of the incidents occurred at fixed facilities and 17% were transportation related (Table 5.2). The origin of the fixed facility incidents was as follows: operational industrial sites (38%), residential premises (25%) commercial premises (11%), agricultural premises (8%), vacant industrial sites (7%), and waste disposal sites (5%). Of the transportation-related incidents, 62% involved transport at sea and 38% occurred on the highway.

Figure 5.5 - Nature of Incidents Reported by Local Authority Environmental Health Departments, Wales, 1993 -1995

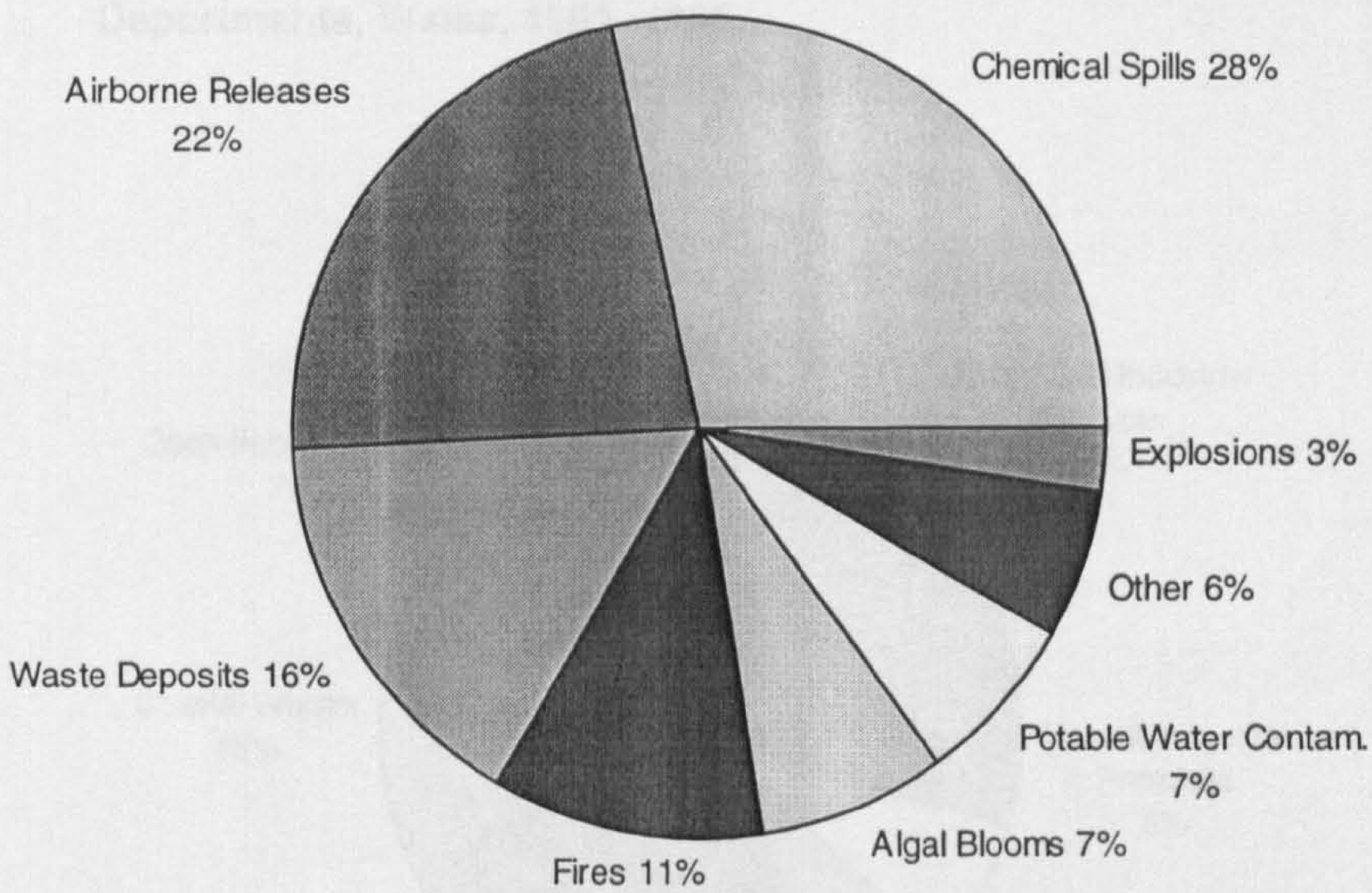


Table 5.2 Classification of 270 chemical incidents according to location, Wales, 1993-1995

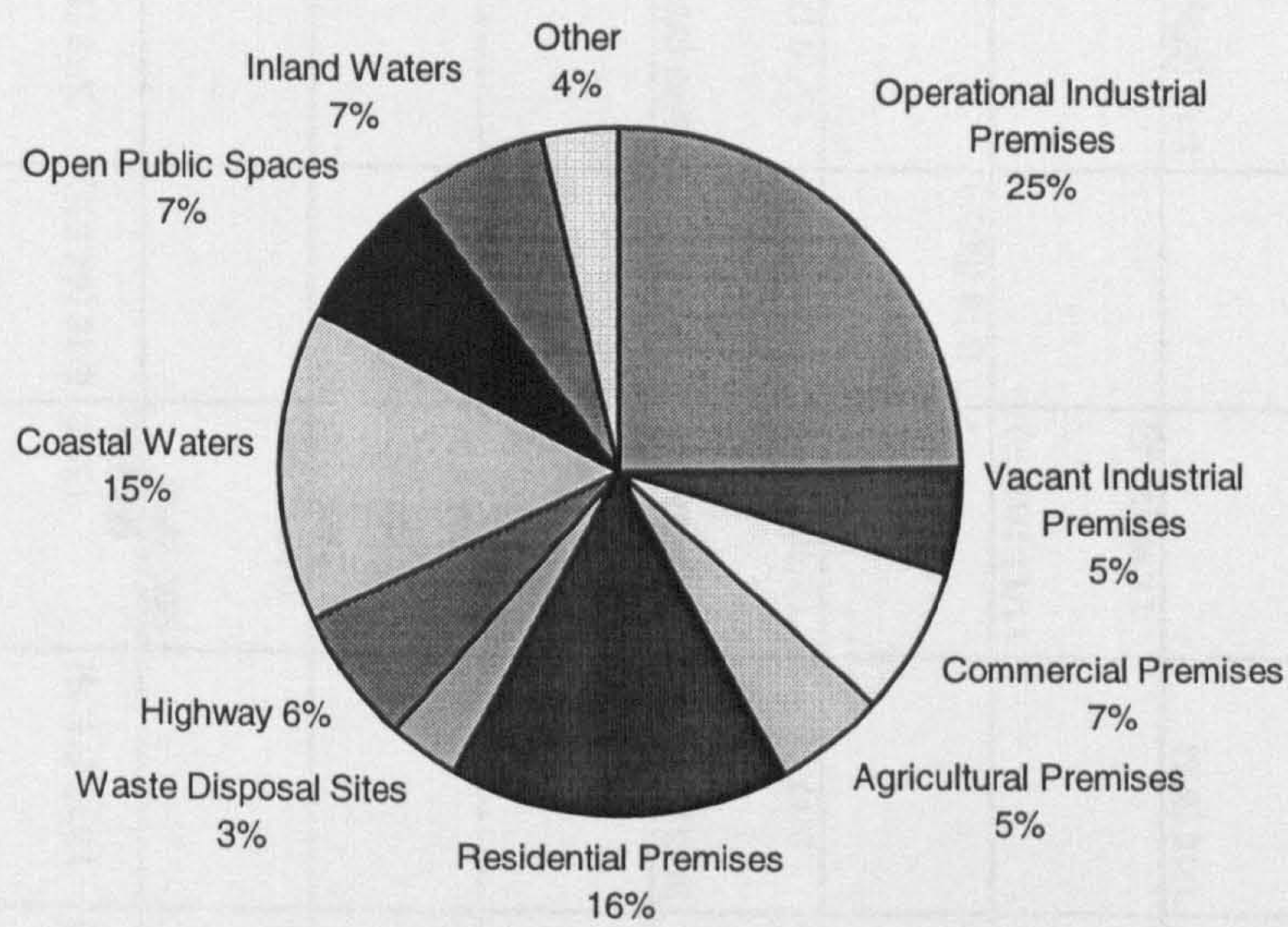
Cause	Fixed facilities	Transportation-related	Other
Number (Percentage)	176 (65%)	45 (17%)	49 (18%)

Overall, the most frequently reported location for incidents (Figure 5.6) were operational industrial sites (25%). Airborne releases (37%), fires (31%) and chemical spills (19%) accounted for the majority of incidents reported at such sites (Table 5.3). At vacant industrial sites (5%), incidents included the discovery of asbestos fibres in broken building products, coal tip fires, acid spills from poorly secured tanks and drums left on site, and methane gas emissions from copper mine shafts.

Drums of chemicals washed ashore on the tide, algal blooms (including "Red Tides" off Pembrokeshire in both 1994 and 1995), and spills of oil and of other chemicals into coastal waters were the most frequent causes of incidents at coastal locations (15%). The occurrence of blue-green algal blooms was also a perennial summer problem of reservoirs in Wales. This included in 1995, the first reported cases of ill-health (skin rashes, vomiting) in users of recreational waters contaminated with such blooms. The other main causes of incidents involving inland waters (7%)

were spillages of raw, untreated sewage into watercourses and the seepage of chemicals from waste materials illicitly deposited on the banks of rivers.

Figure 5.6 Location of Incidents Reported By Local Authority Environmental Health Departments, Wales, 1993 -1995



Spillages of slurry from defective storage tanks and the accidental run-off of herbicides into watercourses following land application were among the incidents reported at agricultural premises (5%), whilst incidents at commercial premises (9%) mainly involved garages and spillages of petroleum and/or diesel oil into drainage systems; leisure centres and emissions of chlorine gas from swimming pool treatment plants; and, supermarkets and leakages of refrigerant gases.

Of most concern at residential premises (16%) were the 11 incidents of carbon monoxide poisoning, which gave rise to 5 fatalities and 23 casualties, the latter all requiring immediate hospitalisation and specialist treatment. Other incidents at residential premises included the chemical contamination of drinking water supplies (34%), exposure to fumes arising from the injection of chemical damp proof courses (14%), and flooding (14%). The latter primarily occurred at coastal locations, but also resulted from the collapse of a canal bank.

TABLE 5.3 - *Number of incidents, reported by nature and location of incident, Wales, 1993 - 1995*

Incident	Operational Industrial	Vacant Industrial	Commercial Premises	Agricultural Premises	Residential Premises	Waste Disposal Sites	Highway	Coastal Waters	Inland Waters	Open Public Spaces	Swimming Pools	Other*	TOTAL
Airborne Release	24/60 (40%) 24/67 (36%)	2/60 (3%) 2/13 (15%)	5/60 (8%) 5/19 (26.5%)	1/60 (1.5%) 1/14 (7%)	19/60 (32%) 19/44 (43%)	4/60 (7%) 4/9 (44%)	1/60 (1.5%) 1/17 (6%)	- -	- -	- -	4/60 (7%) 4/4 (100%)	- -	60 (22%)
Chemical Spill	13/76 (17%) 13/67 (19.5%)	1/76 (1.5%) 1/13 (8%)	7/76 (9%) 7/19 (37%)	8/76 (10.5%) 8/14 (57%)	4/76 (5%) 4/44 (9%)	3/76 (4%) 3/9 (33%)	13/76 (17%) 13/17 (76.%)	15/76 (20%) 15/40 (37.5%)	8/76 (10.5%) 8/18 (44.5%)	3/76 (4%) 3/19 (16%)	- -	1/76 (1.5%) 1/6 (17%)	76 (28%)
Fire	21/30 (70%) 21/67 (31%)	4/30 (13%) 4/13 (31%)	2/30 (7%) 2/19 (10.5%)	2/30 (7%) 2/14 (14.5%)	- -	- -	- -	1/30 (3%) 1/40 (2.5%)	- -	- -	- -	- -	30 (11%)
Explosion	5/7 (72%) 5/67 (7.5%)	- -	1/7 (14%) 1/19 (5%)	- -	- -	- -	- -	1/7 (14%) 1/40 (2.5%)	- -	- -	- -	- -	7 (3%)
Water Contamination	1/18 (6%) 1/67 (1.5%)	- -	2/18 (11%) 2/19 (10.5%)	- -	15/18 (83%) 15/44 (34%)	- -	- -	- -	- -	- -	- -	- -	18 (7%)
Waste Deposit(s)	1/43 (2%) 1/67 (1.5%)	6/43 (14%) 6/13 (46%)	- -	1/43 (2%) 1/14 (7%)	3/43 (7%) 3/44 (7%)	2/43 (5%) 2/9 (23%)	2/43 (5%) 2/17 (12%)	12/43 (28%) 12/40 (30%)	1/43 (2%) 1/18 (5.5%)	15/43 (35%) 15/19 (79%)	- -	- -	43 (16%)
Blue-green algae	- -	- -	- -	- -	- -	- -	- -	- -	9/9 (100%) 9/18 (50%)	- -	- -	- -	9 (3%)
Other algae	- -	- -	- -	- -	- -	- -	- -	11/11 (100%) 11/40 (27.5)	- -	- -	- -	- -	11 (4%)
Other**	2/16 (12.5%) 2/67 (3%)	- -	2/16 (12.5%) 2/19 (10.5%)	2/16 (12.5%) 2/14 (14.5%)	3/16 (18.5%) 3/44 (7%)	- -	1/16 (6%) 1/17 (6%)	- -	- -	1/16 (6%) 1/19 (5%)	- -	5/16 (31%) 5/6 (83%)	16 (6%)
TOTAL	67 (25%)	13 (5%)	19 (7%)	14 (5.5%)	44 (16.5%)	9 (3%)	17 (6%)	40 (15%)	18 (6.5%)	19 (7%)	4 (1.5%)	6 (2%)	270 (100%)

* Other includes Hospitals and Educational Establishments;

** Other includes food contamination, soil contamination and flooding

The fly-tipping of chemicals and chemical wastes in open parkland areas, car parks and the communal areas of residential housing estates was the main cause of incidents reported under the heading "open public spaces" (7%). An incident which highlighted the potential risk that may arise from such indiscriminate dumping occurred in North Wales in October 1994, where the discovery by children of a drum containing sodium sticks resulted in their distribution over a large residential estate and one child being admitted to hospital with severe facial burns.

Seventeen (6%) incidents were reported as having occurred on the highway. These incidents mainly involved chemical spills from tankers following road traffic accidents, and drums and / or other packages of chemicals falling onto the highway from the flatbeds of lorries. A potentially serious incident occurred in January 1995, when a road collapsed below a tanker carrying liquefied petroleum gas. Prompt action to stabilise the tanker prevented any gaseous release and averted the explosive risk to neighbouring properties.

Incidents at waste disposal sites (3%) either involved the detection of elevated and potentially explosive levels of methane in residential properties adjacent to operational or closed landfill sites, or the leaching of waste chemicals into watercourses. The "other" category included four incidents involving the chemical contamination of food. Those of greatest concern were two incidents involving contamination of milk, with naphthalene and 6-chloro-otho-cresol respectively.

The Public Health Impact of Incidents

A total of 237,991 people were reported as having been exposed in the 214 incidents for which information was available (Table 5.4). Fewer than 10 people were exposed in 118 (57.6%) of the incidents. However, thirty incidents were reported where more than 100 people were exposed. The population group most frequently exposed was the general public (236,101 exposed in 201 incidents for which information was available), followed by emergency responders (1591 exposed in 227 incidents for which information was available), and employees of the premises where the incidents occurred (299 exposed in 226 incidents for which information was available).

Table 5.4 - Breakdown of Incidents by Numbers of People Exposed and Population Group, Wales, 1993-1995

NUMBERS EXPOSED	EMPLOYEES		RESPONDERS		PUBLIC		ALL INCIDENTS	
	NUMBER OF INCIDENTS	(%)	NUMBER OF INCIDENTS	(%)	NUMBER OF INCIDENTS	(%)	NUMBER OF INCIDENTS	(%)
0	190	70%	111	41%	81	30%	15	5.5%
1	7	2.5%	8	3%	21	8%	17	6.5%
2 - 4	11	4%	26	10%	28	10%	38	14%
5 - 9	9	3.5%	30	11%	20	7%	47	17.5%
10 - 49	9	3.5%	47	17%	18	7%	60	22%
50 - 99	0	0%	4	1.5%	4	1.5%	7	2.5%
100 >	0	0%	1	0.5%	29	11%	30	11%
Not Stated	44	16.5%	43	16%	69	25.5%	56	21%
TOTAL	270	100%	270	100%	270	100%	270	100%

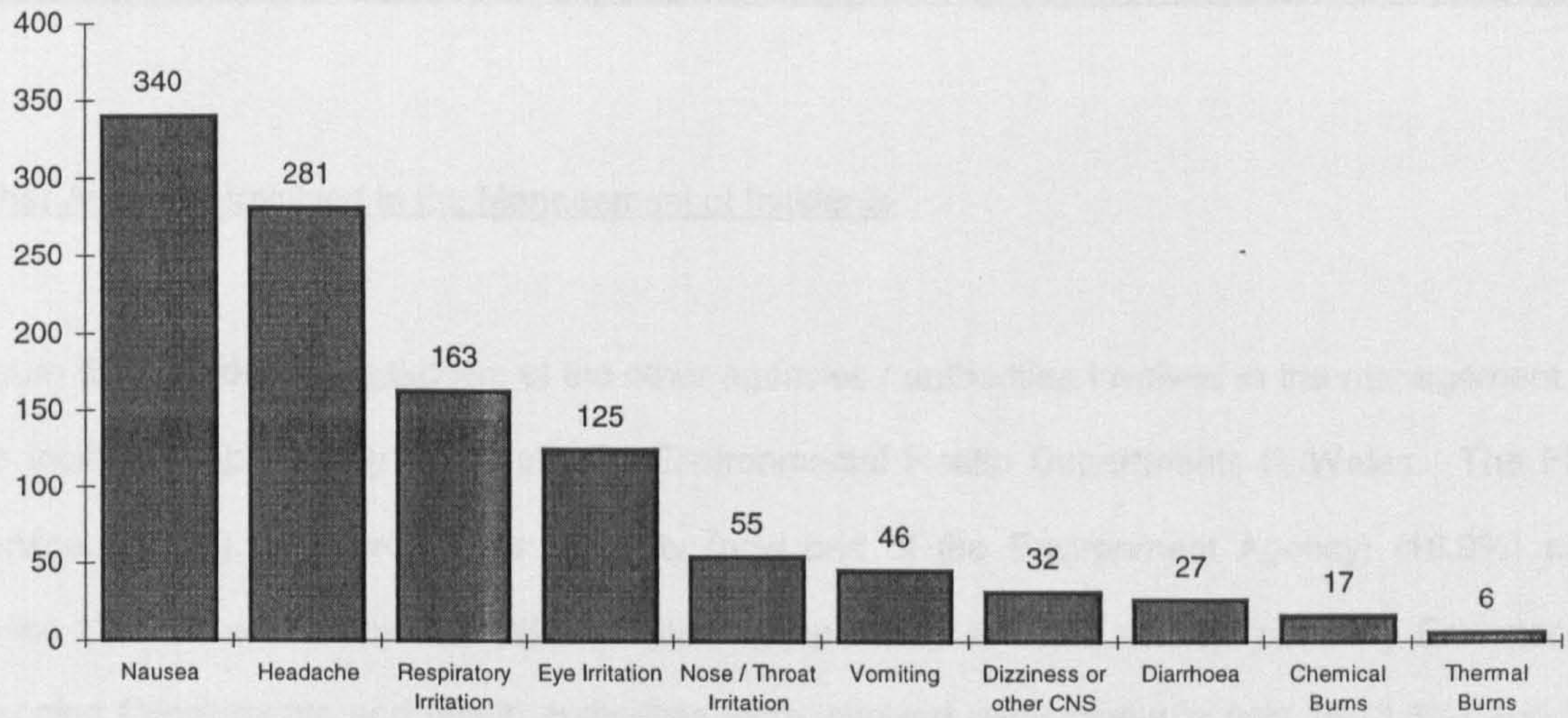
In 57 of the 267 incidents for which information was available, people were also reported as having suffered symptoms (Table 5.5). Although two incidents were reported where exposure led to symptoms in 50 and 120 members of the public respectively, it was reassuring to find that 47 (82.5%) of the 57 incidents involved fewer than 10 people with symptoms. The general public was the population group most frequently reported as having suffered symptoms (a total of 473 in 57 incidents for which information was available), followed by employees of the premises where the incidents occurred (a total of 38 in 10 incidents for which information was available). Of the 1598 responders exposed, it was encouraging to find that only 17 suffered symptoms, which points both to good training and the use of appropriate protective clothing and breathing apparatus by those involved. A total of 6 persons died in 5 incidents. Of those who died, 1 was an employee and 5 were members of the public.

Nausea, headaches, respiratory and eye irritations were the most commonly reported symptoms (Figure 5.7). Other symptoms included irritations of the nose and throat, vomiting, chemical burns, and dizziness or other CNS problems, the latter due mainly to the effects of exposure to carbon monoxide. Although the findings were predictable, it was helpful to have them verified by data.

Table 5.5 **Breakdown of Incidents by Numbers of People with Symptoms and Population Group, Wales, 1993 - 1995**

NUMBERS WITH SYMPTOMS	EMPLOYEES		RESPONDERS		PUBLIC		ALL INCIDENTS	
	NUMBER OF INCIDENTS	(%)	NUMBER OF INCIDENTS	(%)	NUMBER OF INCIDENTS	(%)	NUMBER OF INCIDENTS	(%)
0	260	96.5%	266	98%	218	80%	210	77%
1	3	1%	1	0.5%	15	5.5%	16	5.5%
2 - 4	3	1%	1	0.5%	13	5%	19	7%
5 - 9	4	1.5%	2	1%	10	4%	12	4.5%
10 - 49	0	0%	0	0%	9	3.5%	10	4%
50 - 99	0	0%	0	0%	1	0.5%	1	0.5%
100 >	0	0%	0	0%	1	0.5%	1	0.5%
Not Stated	0	0%	0	0%	3	1%	3	1%
TOTAL	270	100%	270	100%	270	100%	270	100%

Figure 5.7 **Frequency of Symptoms Reported, Wales 1993 - 1995**



Chemicals Released

Details of the actual chemicals released were provided in 223 of the incidents reported. 191 or 85.6% involved the release of a single chemical (Table 5.6). Details of those chemicals appearing three or more times in the database are provided in Table 5.7. For some incidents, only the class of chemical involved is specified.

Table 5.6 Number of Chemicals Released in all Incidents

	INCIDENTS			
NUMBER OF CHEMICALS RELEASED	NUMBER OF INCIDENTS	(%)	NUMBER OF CHEMICALS	(%)
1	191	70.7%	191	58.9%
2	11	4.1%	22	6.8%
3	7	2.6%	21	6.5%
4	2	0.7%	8	2.5%
5	3	1.1%	15	4.6%
6 or more	9	3.3%	67	20.7%
Not Stated	47	17.5%	0	0.0%
TOTAL	270	100%	324	100%

Other Agencies Involved in the Management of Incidents

Figure 5.8 provides a breakdown of the other agencies / authorities involved in the management of the incidents reported by local authority Environmental Health Departments in Wales. The Fire Service (17.5%), National Rivers Authority (now part of the Environment Agency) (16.9%) and Police (11.5%) were those agencies / authorities primarily involved. Local authority Emergency Planning Departments and health authorities were involved respectively in only 18 (3.5%) and 27 (5.2%) of the incidents reported.

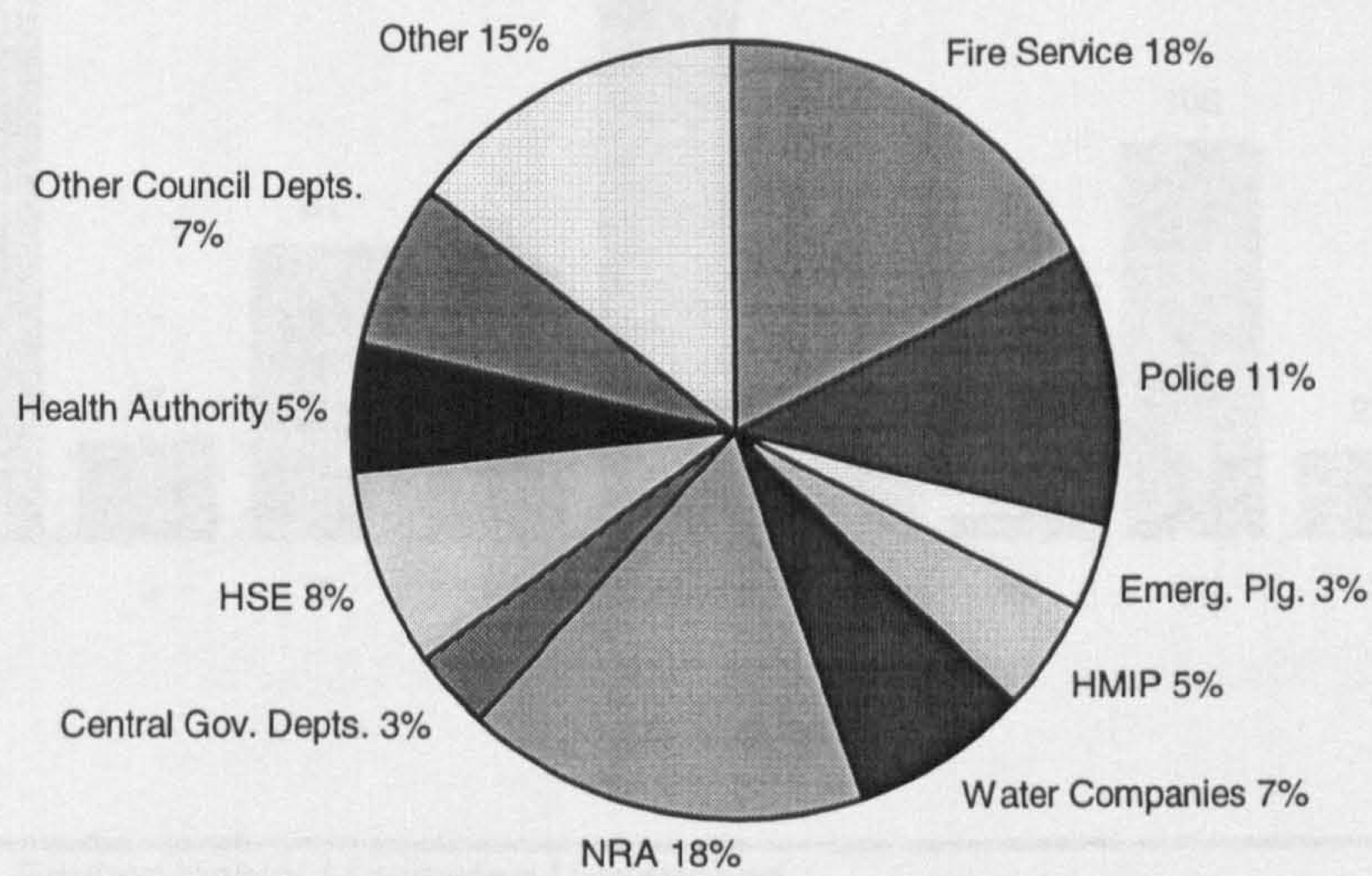
Table 5.7 **Chemicals and Chemical Groups associated with the Incidents Reported by local authority Environmental Health Departments, Wales, 1993-1995**

Chemical/Chemical Group	No.	Chemical/Chemical Group	No.
Smoke toxins	34	Corrosive Liquids - chromic acid, nitric acid, phosphoric acid etc.	5
Volatile Organic Compounds - paints, resins, solvents etc.	20	Clinical waste	5
Particulate matter	14	Herbicides	5
Sewage	14	Sodium / Potassium hydroxide	5
Hydrochloric Acid	11	Red tides - Gymnodinium aureola	5
Petroleum	10	Flammable Liquids ex. propyl alcohol	5
Propane / Butane Gas	10	Radioactive Gases	5
Miscellaneous Oils - heating, waste, steam etc.	10	Methane - landfill gas	5
Heavy Metals - lead, copper, aluminium, iron, manganese, arsenic, mercury	10	Bromine	4
Asbestos	9	Miscellaneous Waste materials	4
Blue-green algae	9	Carbon monoxide	4
Sulphuric acid	8	Di-isocyanates	3
Aromatic hydrocarbons - benzene, PAHs, cresols etc.	7	Agricultural slurry / silage	3
Phaeocystis algal blooms	6	Pesticides	3
Damp Proof Course Injection Fluids	6	Crude oil	3
Chlorine	6	Sodium / Potassium cyanide	3
Diesel Oil	6	Fungicides	3
Hydrogen Sulphide	5	Wartime incendiary devices / nerve gas bombs	3

Actions Taken (Figure 5.9)

Environmental sampling / monitoring was carried out pursuant to 163 (60.4%) of the incidents reported. For incidents involving contamination of water, food and soil, sampling / monitoring had always been undertaken (Figure 5.10). This was not the case, however, in relation to contamination of the atmosphere. Neither sampling nor monitoring had been undertaken in 76.7% of fires, 71.4% of explosions and 41.7% of airborne releases; likewise, in 60.5% of incidents involving exposure to deposits of waste materials and 31.6% of chemical spills.

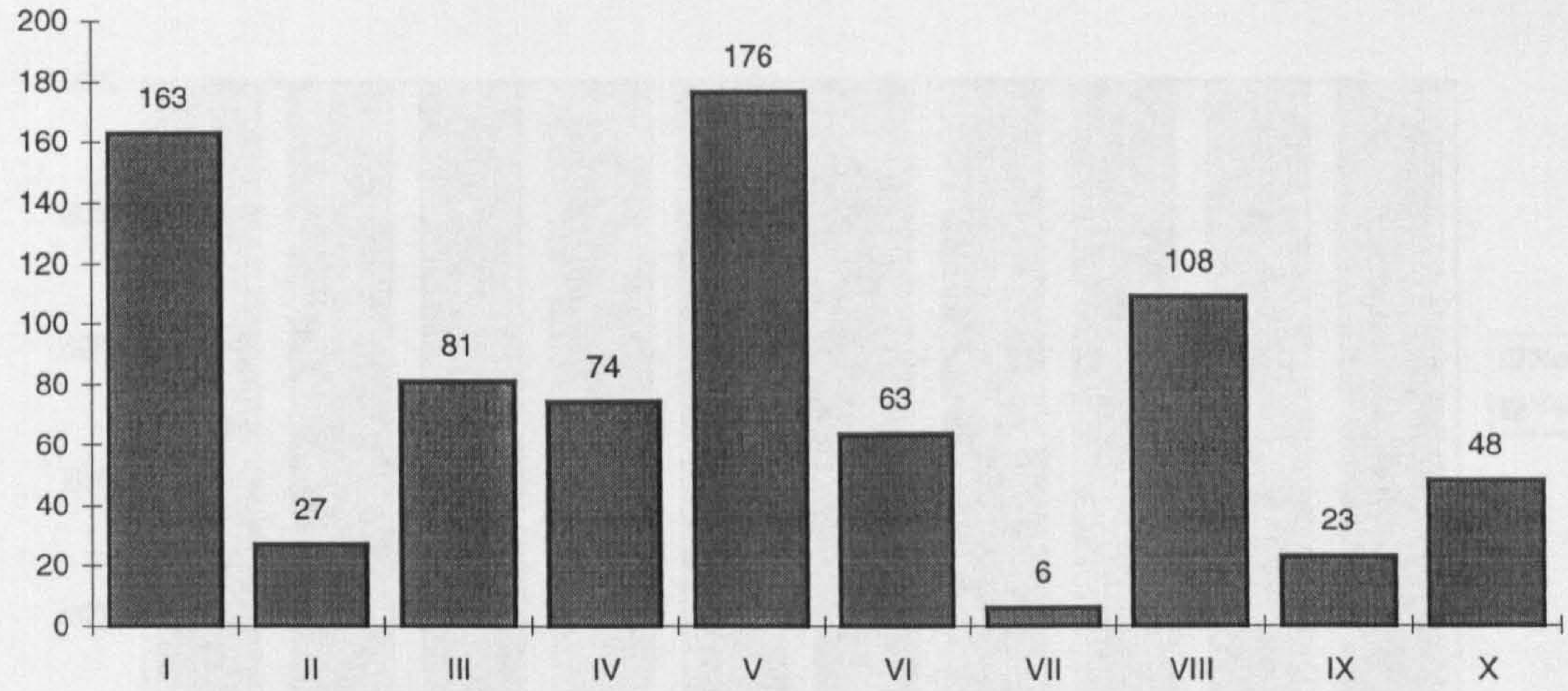
Figure 5.8 **Other Agencies / Authorities Involved in the Management of the Incidents Reported by Local Authority Environmental Health Departments, Wales, 1993 - 1995**



In 27 of the 58 (46.6%) incidents where people had reportedly suffered symptoms, limited forms of "health surveillance" had been undertaken. These comprised primarily medical surveillance of people attending hospital Accident and Emergency Departments and / or GP surgeries, and occupational health surveillance. There were no instances of any formal epidemiological investigations having been instigated. The health authority had provided the lead in relation to 15 of the incidents; the remainder had been carried out by local authority Environmental Health Departments (N = 7) and industry-based occupational health services (N = 5).

"Public health advisories", for example, the erection of warning notices around reservoirs affected by algal blooms, were issued in 81 of the incidents reported. In 74 incidents, persons were evacuated from their homes or advised to stay indoors with windows and doors firmly shut. The category "removal of hazard" embraces the extinguishing of fires, clean up of chemical spills, disposal of drums and packages of chemicals, and excavation of areas of contaminated soil (N = 176).

Figure 5.9 **Actions Taken in relation to the Incidents Reported by Local Authority Environmental Health Departments, Wales, 1993-1995**



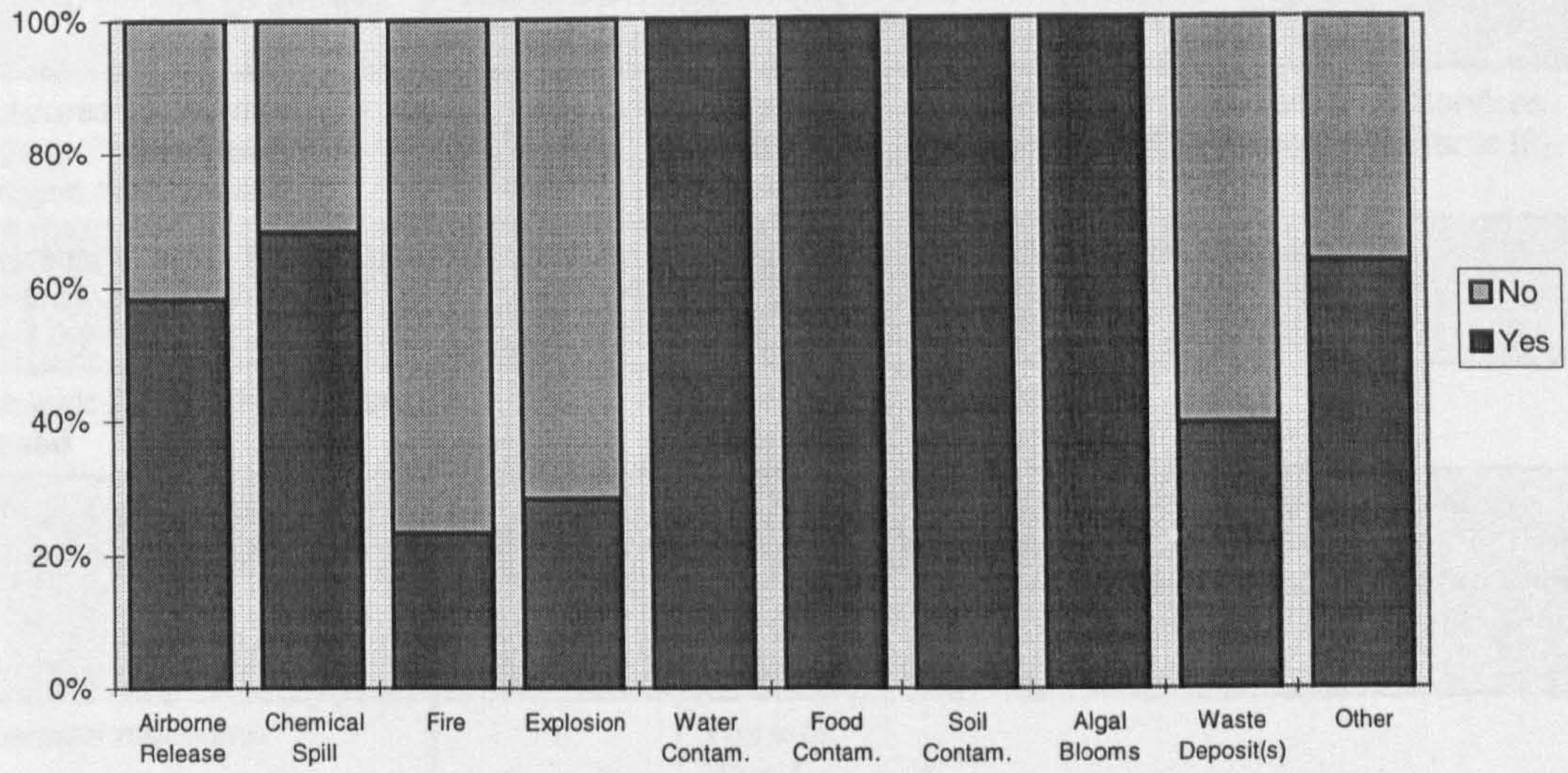
<u>Key</u>

I	Environmental Monitoring Undertaken
II	Health Surveillance Instigated
III	Public Health Advisories Issued (for example, Food Hazard Warnings; Boiling Orders; Bathing restrictions)
IV	Persons Evacuated / In-Place Sheltering Advised / Scene of Incident Sealed Off
V	Removal of Hazard
VI	Risk Mitigation Measures Instituted
VII	Local Authority Emergency Plan Invoked
VIII	Preventative Steps Taken to obviate Recurrence of Incident
IX	Legal Action Taken
X	Informal Warning / Formal Caution Given

The ventilation of residential properties following chemical damp proof course installations and the flushing of water mains pursuant to chemical contamination incidents were among the risk mitigation measures taken (N = 63). Preventative steps (N=108) included changes to work practices, such as the recommendation to move from hot-cutting to cold-cutting techniques in dismantling tanks that had been formally used for the storage of chemicals (following a major fire at a chemicals site in South Wales), and flood alleviation schemes.

Legal actions were pursued in 23 of the incidents reported and formal cautions issued in a further 48 incidents. Local authority emergency plans were invoked on only 6 occasions.

Figure 5.10 Environmental Monitoring Undertaken pursuant to the Incidents Reported by Local Authority Environmental Health Departments, Wales, 1993 - 1995



Advice sought

Tables 5.8, 5.9 and 5.10 provide a detailed breakdown of the technical, scientific and medical advice that was requested by Environmental Health Departments in responding to the incidents reported. Technical advice was that most commonly sought (N = 145), followed by scientific advice (N=115) and medical advice (N = 43). As shown in the tables, advice was generally available, although from a variety of sources, dependent on the nature and location of the incidents. Scientific advice was analysed against the National Academy of Sciences(NAS)/National Research Council (NRC) risk assessment paradigm (NAS/NRC 1983). Advice was most commonly needed in relation to the "Hazard Identification" (N=80) and "Dose-Response Assessment" (N=77) steps of the paradigm. The incidents for which advice was not available (N=11) mainly involved airborne releases from fires and industrial processes, where there were difficulties in both predicting thermal decomposition and/or reactivity products, and accessing suitable continuous monitoring equipment.

Table 5.8 Technical Advice sought by Environmental Health Departments at the time of chemical incidents, Wales, 1993 - 1995 (N = 145)

Nature of Advice Required	Number of Requests	Availability	Source(s) of Advice [N]
Procedures for the safe handling of chemical drums / packages / clinical waste	12	Yes = 7; No = 5	Fire Service [6]; LA Technical Services Department [4]; Private Consultants [2]
Procedures for the decanting of chemicals from damaged tanks / road tankers	4	Yes = 4; No = 0	Industry [2]; Fire Service [2]
Chemicals likely to have been released	8	Yes = 5; No = 3	Industry [5]
Strategies for environmental sampling / monitoring	43	Yes = 38; No = 5	University Departments [5]; Private Consultants [15]; NRA [11]; MAFF [9]; Public Analyst [13]; British Gas [4]; Torrey Research Station [5]; British Geological Survey [1]
Dispersion modelling	1	Yes = 0; No = 1	
Engineering solutions to problems, ex. Methane extraction at landfill sites; safe operation of pipeline systems; demolition procedures	18	Yes = 18; No = 0	Regional Waste Management Groups [6]; HSE [3]; LA Engineering Department [2]; British Waterways [1]; Industry [7]; British Geological Survey [1]
Cause of incident(s), ex. Carbon monoxide / Source of contamination	21	Yes = 20; No = 1	HSE [11]; HMIP [2]; Fire Service [1]; Industry [2]; British Gas [4]; NRA [3]; Water Company [6]; Nuclear Electric [3]
Procedures for containment / neutralisation of chemical spills incl. firefighting waters	14	Yes = 14; No = 0	Fire Service [9]; NRA [9]; LA Technical Services Department [4]
Procedures for isolation / containment of airborne releases	7	Yes = 7; No = 0	Fire Service [5]; Industry [6]; British Gas [1]
Procedures for extinguishing of fires	6	Yes = 6; No = 0	Fire Service [6]; National Farmers Union [1]; International Mining Consultants [1]
Rehabilitation of contaminated soil	7	Yes = 7; No = 0	Industry [5]; Private Consultants [4]; Fire Service [2]; HSE [1]; LA Technical Services Department [1]; Regional Waste Management Group [1]
Rehabilitation of polluted watercourses	4	Yes = 4; No = 0	NRA [4]; Water Company [1]
Removal of asbestos waste products	4	Yes = 5; No = 0	HSE [1]; Private Consultants [5]
Layout of drainage systems	3	Yes = 3; No = 0	LA Technical Services Department [3]; Water Company [1]

Table 5.9 **Scientific Advice sought by Environmental Health Departments at the time of chemical incidents (N = 115)**

Nature of Advice Required	Number of Requests	Availability	Source(s) of Advice [N]
Hazard Identification [Identification and quantification of chemicals involved incl. thermal decomposition products]	80	Yes = 69; No = 11	University Departments [6]; Private Consultants [15]; NRA [21]; MAFF [14]; Public Analyst[20]; HMIP [5]; PHLS [3]; Torrey Research Station [4]; Industry [7]; Water Company [5]; Fire Service [2]; Health and Safety Laboratory [1]; Drinking Water Inspectorate [1]; Nuclear Electric [3]; British Gas [4]
Hazard Assessment [Dose - Response Assessment]	77	Yes = 68; No = 11	University Departments [6]; Private Consultants [14]; NRA [19]; MAFF [14]; Public Analyst[20]; HMIP [5]; PHLS [3]; Torrey Research Station [4]; Water Company [5]; Fire Service [2]; Health and Safety Laboratory [1]; Drinking Water Inspectorate [1]; Nuclear Electric [3]; Industry [5]; British Gas [4]
Risk Evaluation [Exposure Assessment]	21	Yes = 16; No = 5	NRA [11]; MRC Toxicology Unit [1]; MAFF [10]; HMIP [5]; Torrey Research Station [3]; Industry [2]; Fire Service [2]; Water Company [5]; Nuclear Electric [3]
Risk Characterisation **Employee Safety**	9	Yes = 7; No = 2	Health and Safety Executive [6]; Industry [3]; Fire Service [1]; Nuclear Electric [3]
Risk Characterisation **Public Safety**	24	Yes = 18; No = 6	NRA [11]; MRC Toxicology Unit [1]; MAFF [10]; HMIP [5]; Torrey Research Station [3]; Industry [2]; Fire Service [2]; Water Company [5]; Nuclear Electric [3]

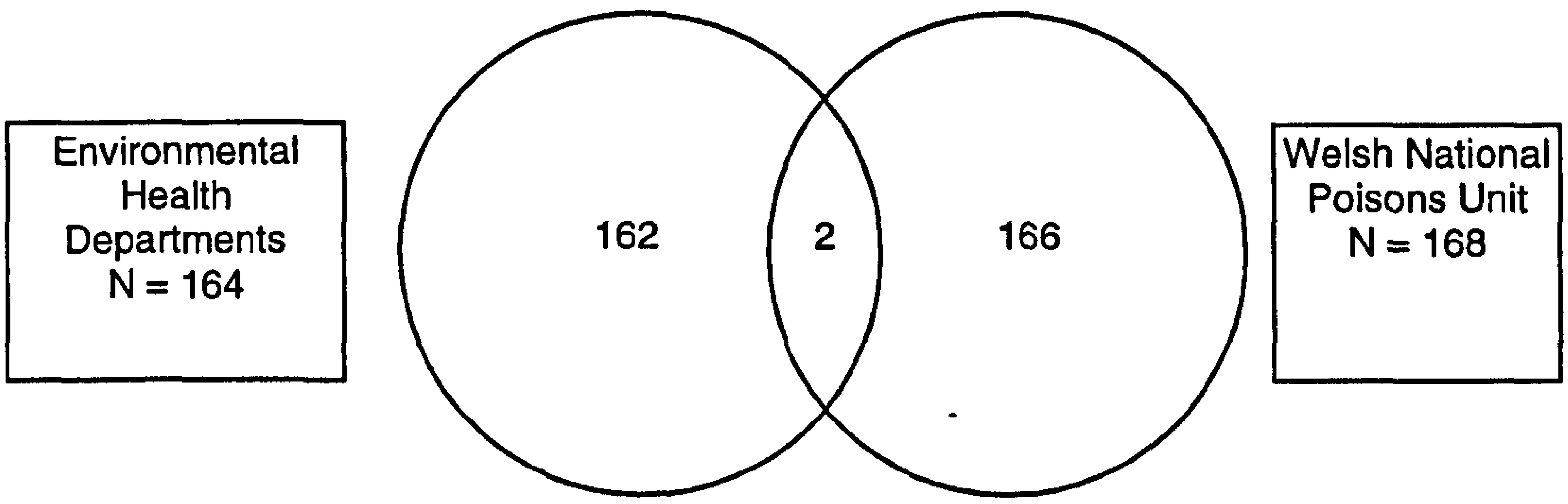
Table 5.10 - **Medical Advice sought by Environmental Health Departments at the time of chemical incidents (N = 43)**

Nature of Advice Required	Number of Requests	Availability	Source(s) of Advice (N)]
Clinical management	19	Yes = 19; No = 0	Accident and Emergency Department [14]; General Practitioner [4]; Specialist Treatment Facility [4]; Ambulance Service [4]; Welsh National Poisons Unit [3]
Likely adverse health effects of exposure (acute / chronic)	18	Yes = 14; No = 4	Health Authority [10]; HSE [1]; Fire Service [1]; MAFF [1]; Welsh National Poisons Unit [1]
Occupational health surveillance	8	Yes = 8; No =0	Occupational Health Department, Hospital [1]; Health Authority [1]; Industry [6]

Welsh National Poisons Unit

In January 1994, a separate reporting system was established with the Welsh National Poisons Unit. As will be evident from the results presented below, the Unit mainly recorded incidents, where people had been referred to Accident and Emergency Departments for treatment following accidental exposure to chemicals. The Unit therefore provided a very useful supplementary reporting system to that implemented with local authority Environmental Health Departments in Wales.

Figure 5.11 Distribution of 332 incidents by reporting source, Wales, 1994-1995



<u>The Number of Incidents</u>

A total of 168 incidents were reported by the Welsh National Poisons Unit for the period 1 January 1994 to 31 December 1995. A comparative analysis of the incidents reported by the Unit with those recorded by local authority Environmental Health Departments for the same period revealed only 2 incidents as being common to both systems (Figure 5.11). This can probably be attributed to the very different sources of initial notification of incidents to each system. Reports of acute chemical incidents mainly came to the attention of the Welsh National Poisons Unit through calls received from hospital A&E Departments (76%) and General Practitioners (13%).

The Nature and Location of Incidents

As for the system developed with local authority Environmental Health Departments, chemical spills (48.7%) constituted the most frequently reported type of incident, followed by airborne releases (29.7%) and fires (8.2%) (Figure 5.12) There was, however, a marked difference in the locations of the incidents reported by the two systems. Figure 5.13 shows that 78 per cent of the incidents reported by the Welsh National Poisons Unit occurred at operational industrial premises. In contrast, only 25 per cent of the incidents reported by local authority Environmental Health Departments occurred at such premises (see Figure 5.6 above). Other locations included commercial premises (7%), educational establishments (4%) and hospital premises (4%).

The Public Health Impact of the Incidents Reported

As the calls handled by the Unit related mainly to people who were attending hospital A&E Departments or general practitioner's surgeries for treatment, the numbers exposed were known in 97.1 per cent of the incidents reported (Table 5.11). This compared with a figure of 79 per cent for incidents reported by local authority Environmental Health Departments (see Table 5.4 above). A total of 361 people were reported as having been exposed in the 163 incidents for which information was available. Eighty-four per cent of the incidents involved the exposure of just one individual, and in only 9 incidents were five or more people exposed. The population group most frequently exposed were employees of the premises where the incidents occurred (214 exposed in 163 incidents for which information was available), followed by the general public (89 exposed in 165 incidents for which information was available) and emergency responders (58 exposed in 166 incidents for which information was available). This was in marked contrast to the incidents reported by local authority Environmental Health Departments, where employees were the population group least frequently exposed.

Figure 5.12 **Nature of Incidents Reported by the Welsh National Poisons Unit, Wales, 1994-1995**

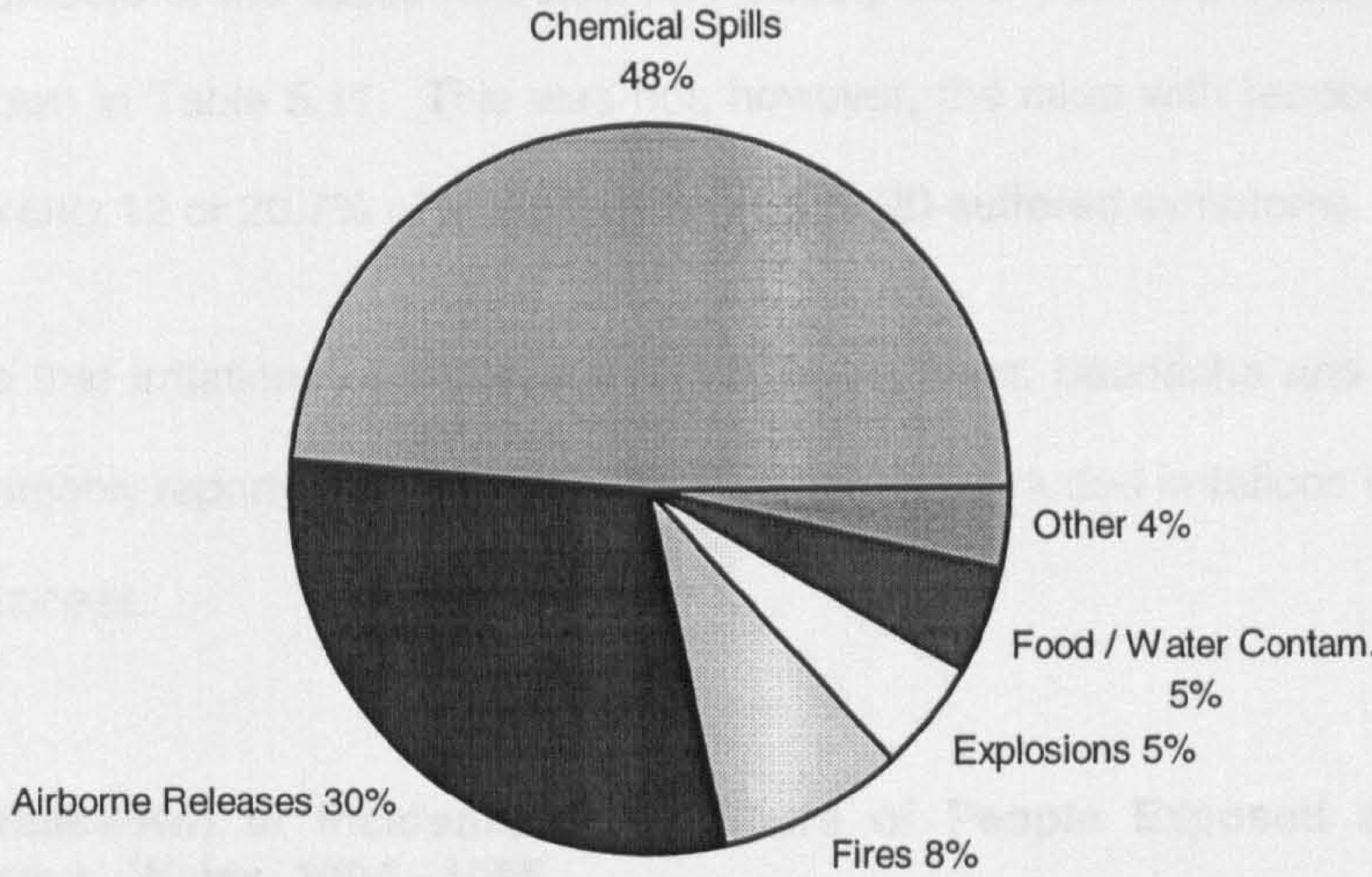
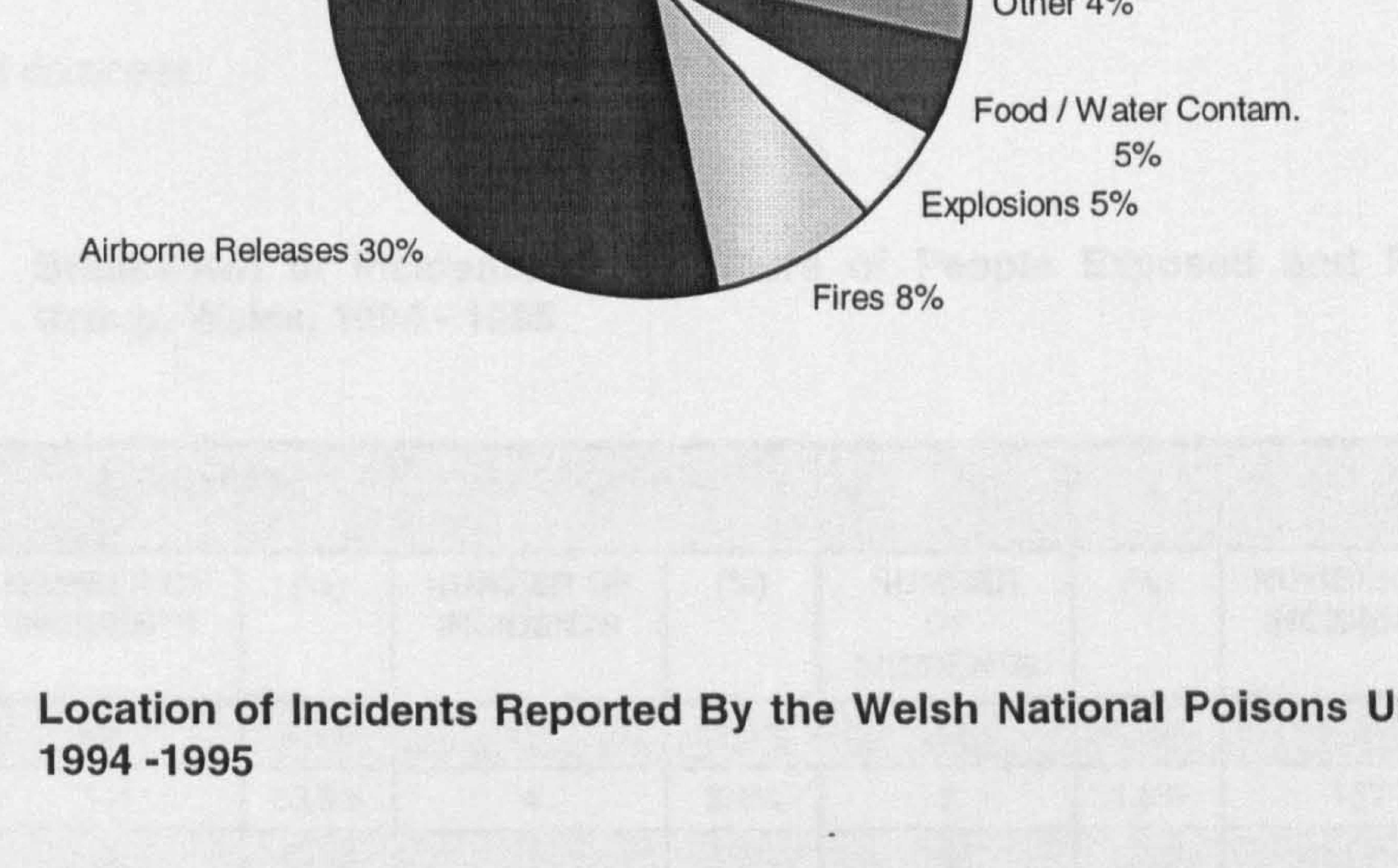


Figure 5.13 **Location of Incidents Reported By the Welsh National Poisons Unit, Wales, 1994 -1995**



In 153 or 91.6% of the 167 incidents for which information was available, people were also reported as having suffered symptoms (Table 5.12). Accordingly, the symptom prevalence rates in employees and members of the public reflected very closely the exposure prevalence rates for the two groups, as shown in Table 5.11. This was not, however, the case with respect to emergency responders, where only 12 or 20.7% of those exposed (N = 58) suffered symptoms.

Figure 5.14 shows that irritations of the eye and respiratory tract, headache and chemical burns were the most commonly reported symptoms. Other symptoms included irritations of the skin, nose and throat, and dizziness.

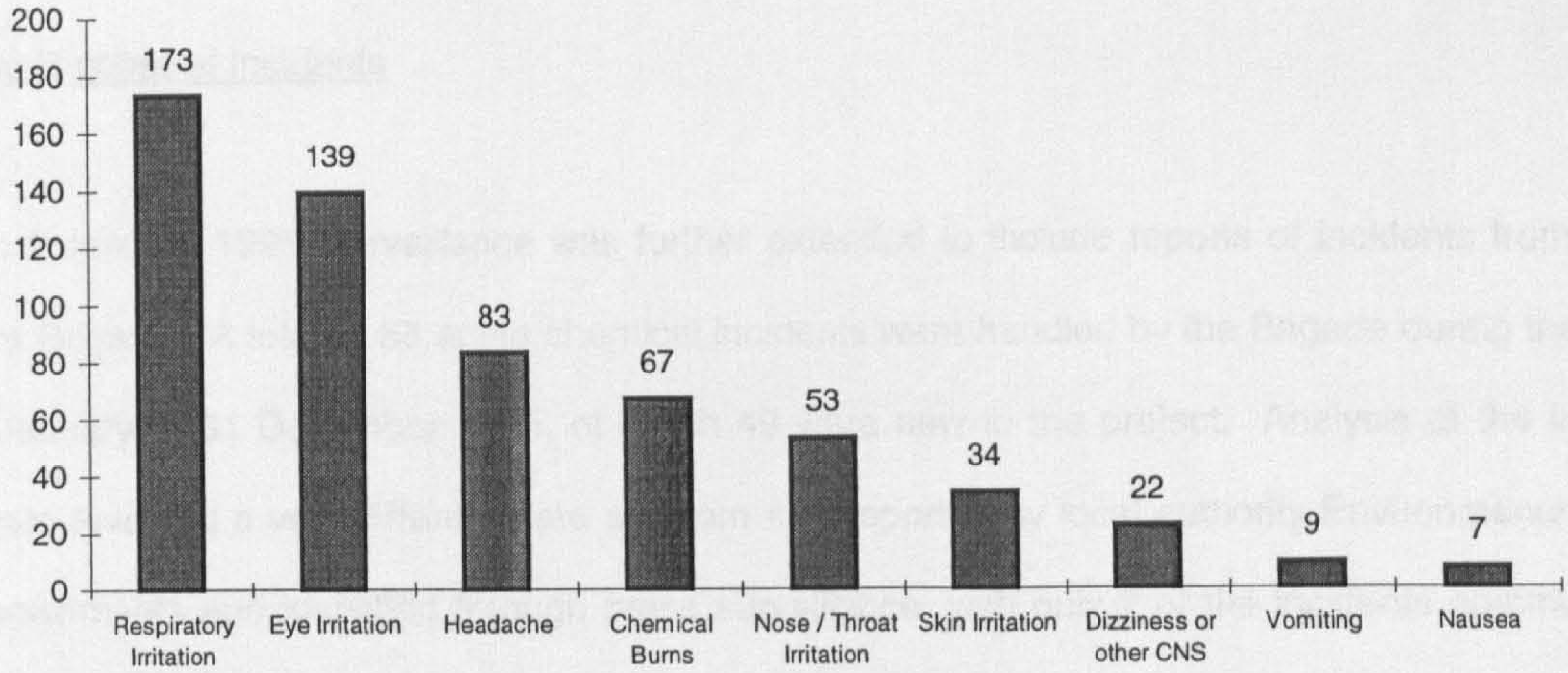
Figure 5.11 Breakdown of Incidents by Numbers of People Exposed and Population Group, Wales, 1994 - 1995

NUMBERS EXPOSED	EMPLOYEES		RESPONDERS		PUBLIC		ALL INCIDENTS	
	NUMBER OF INCIDENTS	(%)	NUMBER OF INCIDENTS	(%)	NUMBER OF INCIDENTS	(%)	NUMBER OF INCIDENTS	(%)
0	9	5.4%	155	92.2%	156	92.8%	2	1.2%
1	141	83.9%	4	2.4%	3	1.8%	137	81.6%
2 - 4	9	5.4%	1	0.6%	4	2.4%	15	9%
5 - 9	2	1.2%	4	2.4%	1	0.6%	3	1.8%
10 - 49	2	1.2%	2	1.2%	0	0	5	2.9%
50 - 99	0	0	0	0	1	0.6%	1	0.6%
100 >	0	0	0	0	0	0	0	0
Not Stated	5	2.9%	2	1.2%	3	1.8%	5	2.9%
TOTAL	168	100%	168	100%	168	100%	168	100%

Figure 5.12 Breakdown of Incidents by Numbers of People with Symptoms and Population Group, Wales, 1994 - 1995

NUMBERS WITH SYMPTOMS	EMPLOYEES		RESPONDERS		PUBLIC		ALL INCIDENTS	
	NUMBER OF INCIDENTS	(%)	NUMBER OF INCIDENTS	(%)	NUMBER OF INCIDENTS	(%)	NUMBER OF INCIDENTS	(%)
0	18	10.7%	163	97%	158	94%	13	7.8%
1	135	80.3%	1	0.6%	3	1.8%	134	79.7%
2 - 4	9	5.4%	2	1.2%	4	2.4%	13	7.8%
5 - 9	3	1.8%	1	0.6%	1	0.6%	5	2.9%
10 - 49	1	0.6%	0	0	0	0	1	0.6%
50 - 99	0	0	0	0	1	0.6%	1	0.6%
100 >	0	0	0	0	0	0	0	0
Not Stated	2	1.2%	1	0.6%	1	0.6%	1	0.6%
TOTAL	168	100%	168	100%	168	100%	168	100%

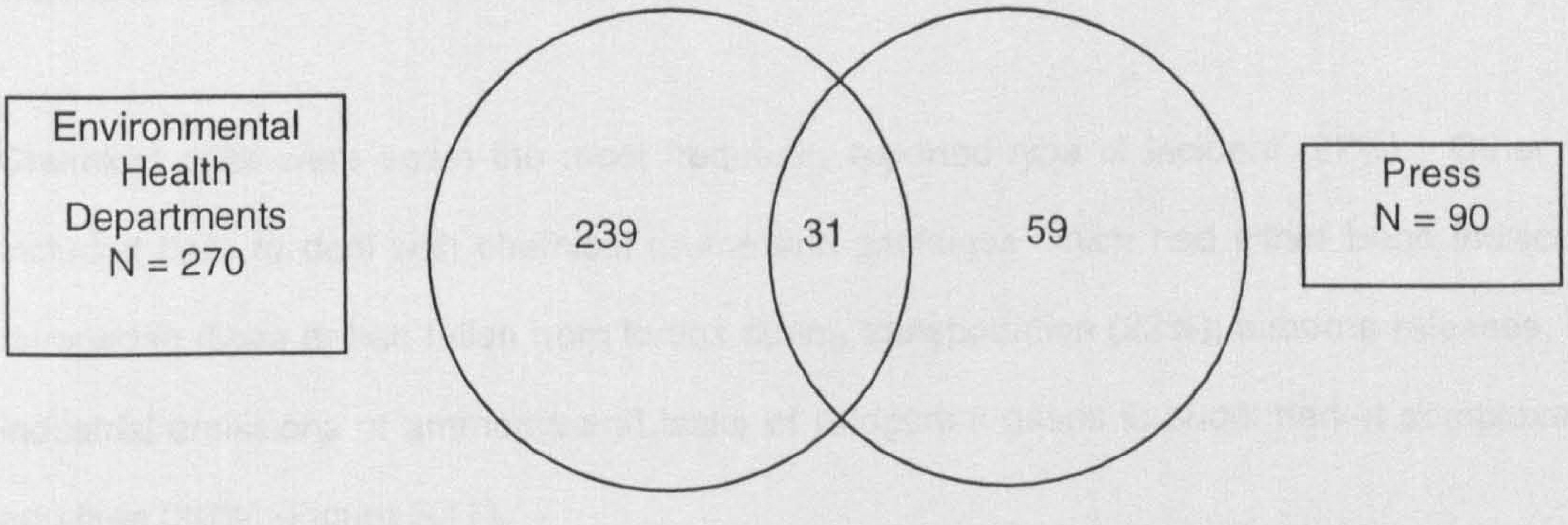
Figure 5.14 Frequency of Symptoms Reported, Wales 1994 - 1995



Press Surveillance

On 1 January 1993, systems were established for the routine monitoring of national and local newspapers throughout Wales. A total of 90 incidents were identified through this activity, of which 59 were new to the project. Only a third of the incidents identified through press surveillance had been reported by local authority Environmental Health Departments (Figure 5.15). The information contained within the press cuttings was, however, variable in terms of both its accuracy and validity, and no further analyses are presented here. Although difficult to qualify, the press cuttings did highlight the political and public perceptions often surrounding the incidents reported, information which was hard to record on the reporting forms developed for the project.

Figure 5.15 Distribution of 332 incidents by reporting source, Wales, 1993 - 1995

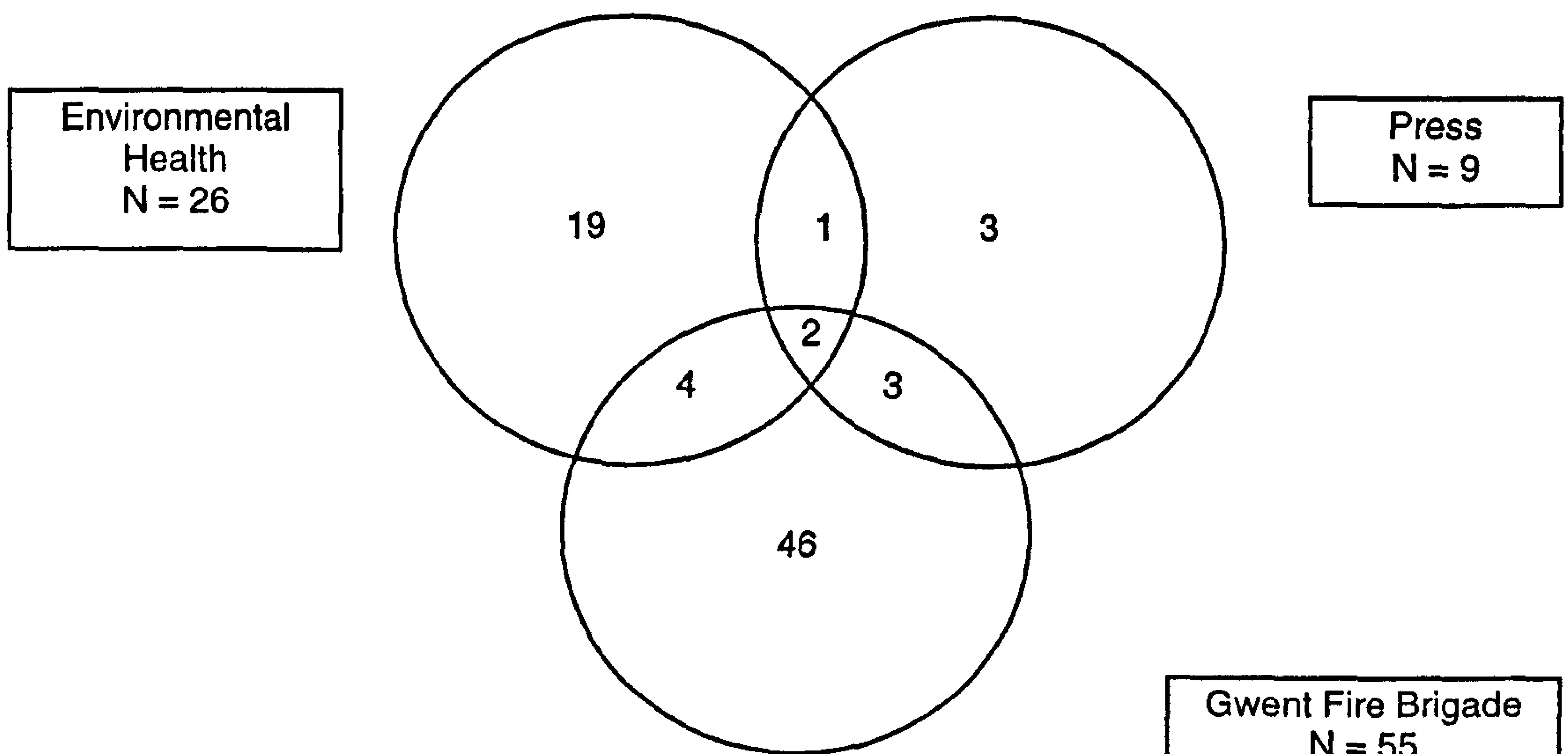


Gwent Fire Brigade

The Number of Incidents

On 1 January 1995, surveillance was further extended to include reports of incidents from Gwent Fire Brigade. A total of 55 acute chemical incidents were handled by the Brigade during the period 1 January to 31 December 1995, of which 49 were new to the project. Analysis of the incidents again revealed a very different data set from that reported by local authority Environmental Health Departments and identified through press surveillance, with only 2 of the incidents common to all three systems (Figure 5.16).

Figure 5.16 Distribution of 90 incidents by reporting source, Gwent, 1995



The Nature and Location of Incidents

Chemical spills were again the most frequently reported type of incident (27%). Other incidents included calls to deal with chemical drums and packages which had either been indiscriminately dumped in rivers or had fallen from lorries during transportation (22%); airborne releases, including industrial emissions of ammonia and leaks of refrigerant gases in supermarket complexes (22%); and fires (20%) (Figure 5.17).

Figure 5.17 Nature of Incidents Reported by Gwent Fire Brigade, Gwent, 1994-1995

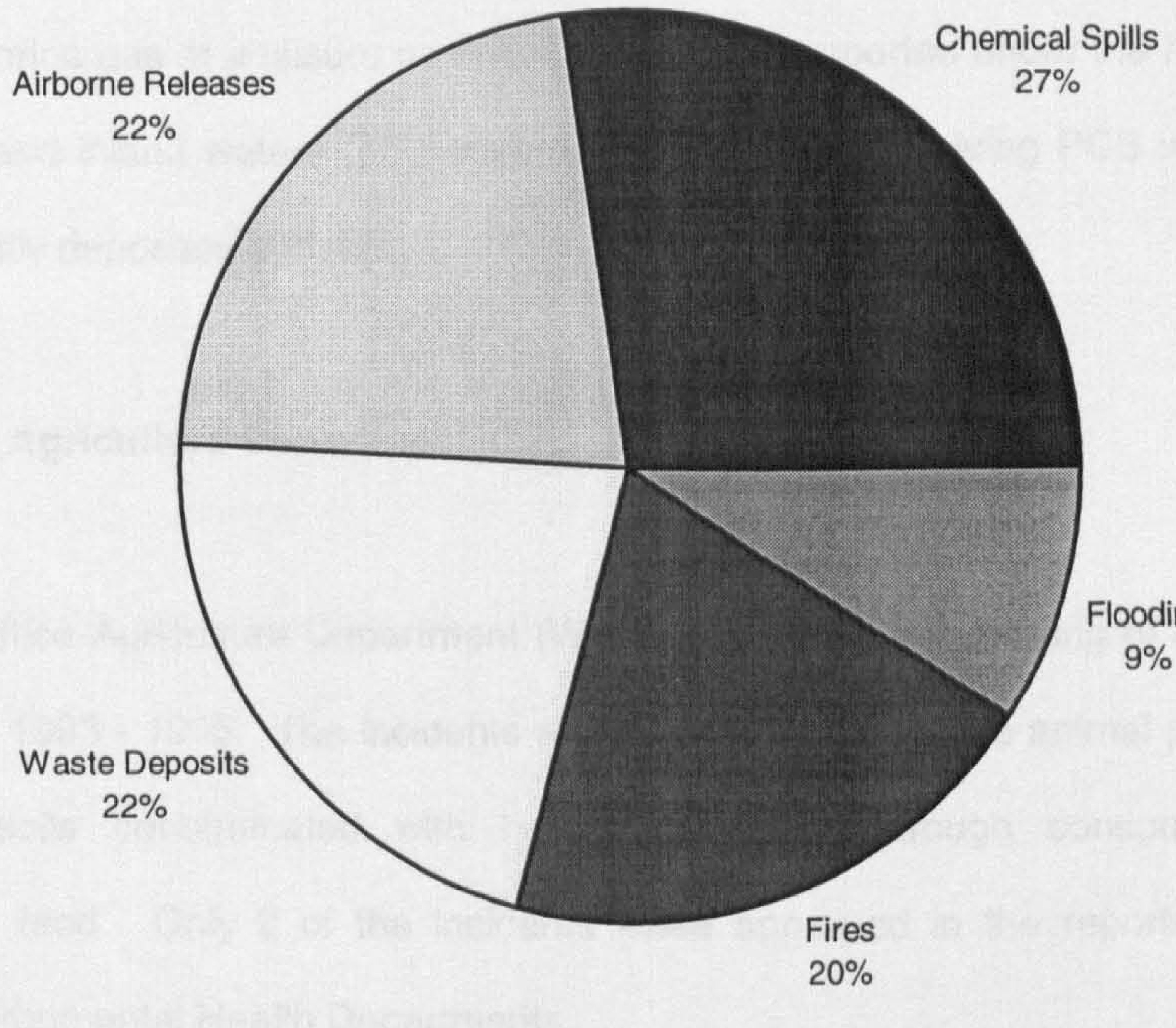
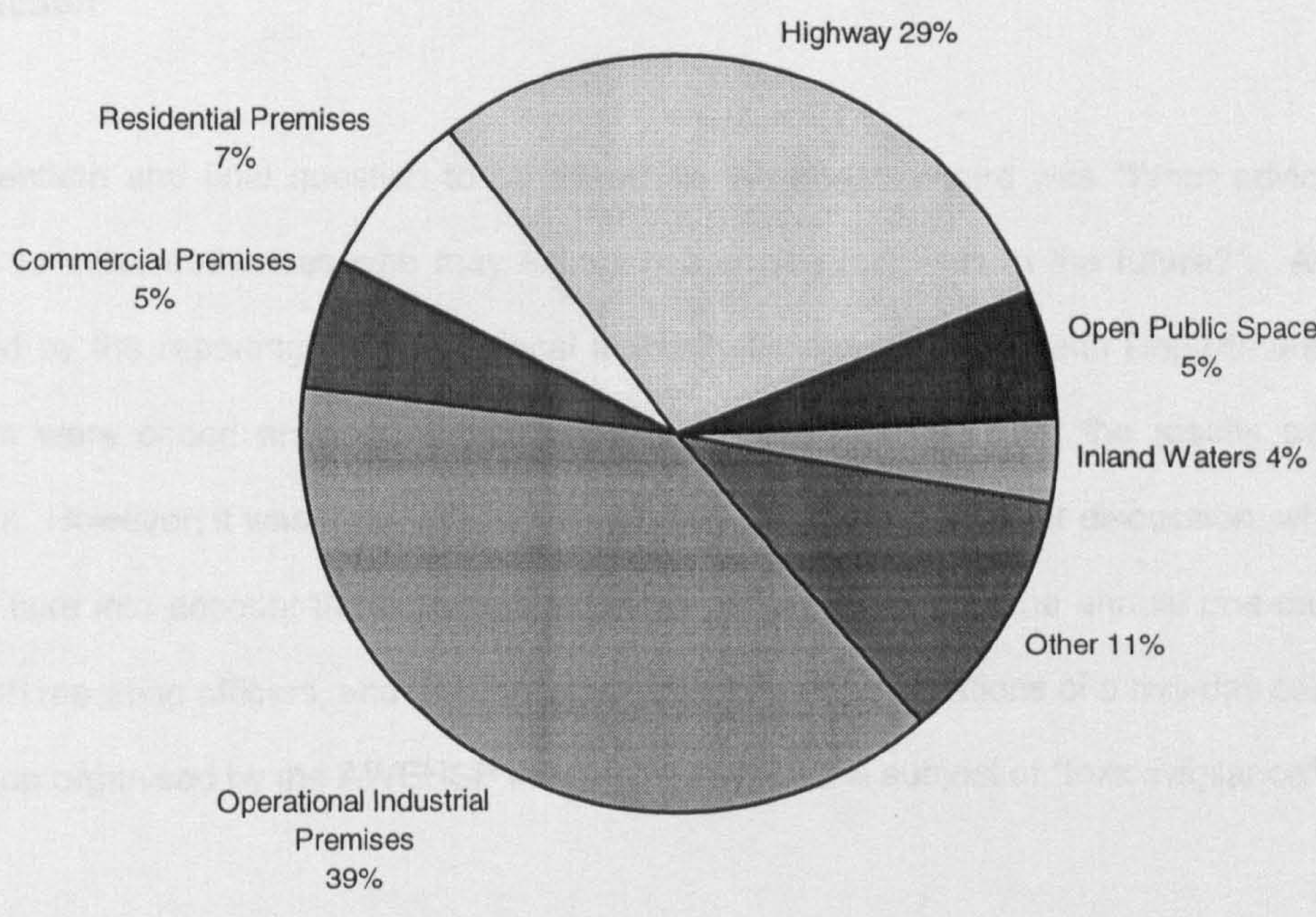


Figure 5.18 Location of Incidents Reported by Gwent Fire Brigade, Gwent, 1995



Operational industrial premises were the most frequent incident location (39%) (Figure 5.18). Incidents on the highway (29%) were also common. A smaller number of incidents were reported at residential properties (7%) including flooding, domestic gas leaks and exposure to freons following damage to a domestic refrigerator. Incidents at commercial premises (5%) included a release of chlorine gas at a leisure complex, whilst those reported under the headings "open public space" (5%) and inland waters (4%) covered a rubbish fire involving PCB wastes, and drums of chemicals illicitly deposited in rivers.

Welsh Office Agriculture Department

The Welsh Office Agriculture Department (WOAD) provided a line-listing of 84 incidents recorded for the period 1993 - 1995. The incidents reported related mainly to animal poisonings, caused by grazing on soils contaminated with heavy metals or through consumption of chemically contaminated feed. Only 2 of the incidents listed appeared in the reports received from local authority Environmental Health Departments.

Discussion

Introduction

The twentieth and final question to be asked on the questionnaire was "What advice would you provide to other authorities who may experience similar incidents in the future?". Answers were provided by the reporting officers of local authority Environmental Health Departments only. The answers were coded and could have been presented directly under the results section of this Chapter. However, it was decided to present these as part of a broader discussion, which was also able to take into account the notes made by the author at each of the annual one-day workshops held with reporting officers, and the conclusions and recommendations of a two-day conference and workshop organised by the AWEHSP in March 1994, on the subject of "toxicovigilance".

The aim of the conference and workshop was to provide guidance to health authorities in Wales on meeting the requirements placed upon them by Welsh Office circular WHC (93) 61 (see Chapter 4 and Appendix 5.4). This was to be primarily achieved through raising the awareness of emergency services in Wales to the public health dimensions of the response to acute chemical incidents, thereby facilitating the inclusion of health authority representation (probably the CCDC) within the classical "Incident Command System" of emergency management. The conference, which was open to all, attracted 86 delegates on day 1, with 46 accepting the invitation to attend a closed workshop on day 2. The latter were drawn from the full range of response agencies and authorities in Wales.

The following therefore represents a combined and evaluated appraisal of the three elements described above. However, the bias will be towards local authority Environmental Health Departments, not only by reason of their reporting officers having provided the answers to question 20, but also because in three years of surveillance, there was little evidence to suggest that health authorities were any more involved in managing the public health aspects of acute chemical incidents than they were before the introduction of WHC (93)61. Of the 270 acute chemical incidents reported by local authority Environmental Health Departments in Wales over the three years of the project, the CsCDC of HAs were involved in just 27 (10%). The section is separated into three parts: emergency planning and preparedness, incident response and follow-up.

Emergency Planning and Preparedness

Integrated Emergency Management

There was general agreement that an "Integrated Emergency Management" (IEM) approach to chemical incident preparedness, planning and response was needed (see Chapter 4). This was largely dependent on the ability of emergency plans to successfully integrate the contributions of a large number of different agencies and authorities.

Roles and Responsibilities

Whilst the roles and responsibilities of local authority Environmental Health Departments were clearly stated in emergency plans, the contribution that they were actually expected to make was not uniform throughout Wales and often lacked clarity. Instances were cited where they were counted upon to provide immediate advice at the scene of an incident on the need for evacuation of residents and / or on the potential health risks to exposed communities. However, the officers involved were often unable to give the necessary critical advice, in the absence of, for example, front-line information on the toxicology of the chemicals released and their potential decomposition reaction products.

The following were therefore emphasised as important considerations for all local authority Environmental Health Departments in Wales:

(a) to determine the roles and responsibilities of the Department internally, in relation to likely incident scenarios;

(b) to jointly investigate the roles and responsibilities perceived of the Department by other local response agencies, in relation to likely incident scenarios; this was viewed as particularly important in clarifying the complementary roles of HAs;

(c) to examine the cost implications of providing these roles and responsibilities, for example, in undertaking environmental monitoring, disposal of chemical drums etc.;

(d) to pre-identify where appropriate support, advice and consultancy services can be readily accessed in situations where in-house expertise is lacking, for example, confirming that symptoms in the population can be attributed to the toxicological properties of the chemicals involved;

(e) to provide officers with pocket-size emergency procedures manuals, clearly delineating the roles and responsibilities of all response agencies; and giving the names and contact details of relevant counterparts within other agencies; and

(f) to ensure that plans are regularly updated to take account of staff changes and departmental reorganisations.

Communications

The importance of joint planning in communications was also highlighted. This included the need for familiarity with the forms, terminology and information technology used by other response agencies, and consideration of the requirements to equip the Department's officers at the scene of the incident with their own communications, for example, mobile phones.

Best Practice Guides

Linked to emergency planning were a number of suggestions intended to underpin the philosophy of joint working between local authority Environmental Health Departments and the other response agencies / authorities. These included the collaborative development of:

(a) risk assessment guidelines with health authorities to support public health decision-making at the time of chemical incidents;

(b) best practice protocols and joint methods of working with the emergency services for the safe handling and disposal of illicitly dumped chemical drums and containers;

(c) inter-departmental policies for the safe handling and disposal of clinical waste found on beaches, in open parkland areas etc.; and

(d) evidence-based guidance on the health risks associated with the explosive release of asbestos fibres during fires, both at the time of the incident and during the subsequent clean-up operations.

Community Preparedness

There was also scope for wider dialogue between local authorities, health authorities, other response agencies, industry and the community in relation to programmes of community preparedness. Where undertaken, the benefits had been clearly demonstrated, in terms of the effective pre-briefing of populations living in close proximity to major hazard sites, both in relation to the inherent risks posed by the chemicals stored or processed therein, and the precautionary actions to be taken in the event of an incident.

Hazard Assessment

Although the perennial problems of staffing shortages and cutbacks in local authority funding were much in evidence in the responses received, a number of reporting officers felt that it would be in their authority's best interests to adopt a more strategic approach to the assessment of potential hazards within their respective areas.

The CIMAH database at the Welsh National Poisons Unit was considered an important resource. However, it covered only a limited number of sites. It was therefore left to local authorities, in consultation with industry and other response agencies, to build up their own information resources on chemicals held at industrial premises within their respective areas, both as a means of identifying possible emergency situations and ensuring the availability of appropriate expertise and facilities for response. In compiling this knowledge base, recommendations included:

a) the review of records held on particular premises, for example, COSHH assessments obtained under the provisions of health and safety legislation, to identify the presence of hazardous chemicals, the quantities held, and the potential release scenarios;

b) improved liaison and co-operation with other agencies, particularly the Fire Service and the National Rivers Authority (now part of the Environment Agency), known to have formal responsibilities respectively in relation to the conduct of fire safety assessments at industrial premises, and the issue of pollution discharge consents to local industries;

c) mapping the location of potential sources of pollution to watercourses, including storm water overflows, farm slurry/silage lagoons, waste disposal sites, areas of contaminated land and discharge points from local industries; and

d) auditing the lessons learned from the investigation of previous incidents or near misses, particularly those with a tendency to occur perennially, for example, the proliferation of blue-green algal blooms in local lakes and reservoirs during the summer months.

Likewise, liaison and close co-operation with local fire and police services, customs officials and industry, was seen as essential in gaining relevant information on the nature and extent of chemicals being transported by road, rail and sea within a local authority's area.

Sensitive Areas / Populations

Many of those reporting officers who were in favour of the above approach also raised as a complementary activity the need for increased awareness of the populations and/or environments likely to be affected in the event of an incident, for example, the location of potential pollution impact sites downstream of incidents involving chemical spills into watercourses. These might include shellfish beds, water treatment abstraction points, fish farms and recreational water users.

With respect to populations, knowledge of the position of residential estates, schools, hospitals and care homes for the elderly in relation to operational industrial sites, contaminated land etc. was perceived as important both in better quantifying those members of the community at heightened risk and in prioritising the siting of environmental monitoring equipment.

District Surveillance

Reference has already been made to the fact that 30 or 10 per cent of the 270 incidents reported by local authority Environmental Health Departments were initially identified through routine district surveillance activities. The continued resourcing of these statutory and non-statutory activities, including the maintenance of programmes of environmental sampling and monitoring, was perceived as particularly important in:

(a) ensuring the early detection of incidents, for example, of blue-green algal blooms in recreational waters;

(b) recognising hazardous situations before problems arise, for example, improper storage of gas cylinders, illegal tyre dumps, and damage to asbestos-containing materials in public buildings;

(c) identifying elevated levels of chemical contaminants in public and private water supplies, and, similarly, raised methane gas levels around landfill sites; and

(d) surveying their areas for sites of contaminated land.

Training and Education

Training and education were considered important facets of any schemes of chemical incident preparedness. Specifically highlighted was the need for joint theoretical and practical training in the implementation of mutually agreed local emergency plans and best practice guides.

It was also recommended that local authority CEHOs conduct a training needs analysis of their respective Departments, so as to ensure the availability on a 24 hour basis of staff with the necessary skills to fulfil the roles and responsibilities expected of them at the scene of an incident, for example, knowledge in the use of environmental monitoring equipment. Alternatively, suggestions were made that neighbouring authorities might consider entering into agreements for the exchange of specialists to provide mutual support in incident response situations.

Incident Response

Out of Hours Arrangements

The capability to immediately attend the scene of an incident was considered an important factor in eliciting an effective environmental / public health response. Although costly, the retention of coverage on a 24-hour, 365 day basis was felt to be essential.

Health and Safety

Incidents were also reported where officers of various response agencies themselves fell victim to symptoms of chemical exposure. The provision of suitable personal protective equipment and relevant safety training was therefore considered essential, particularly in relation to circumstances where response personnel were:

(a) involved in the cleaning of beaches, inland waterways, and of residential and other premises contaminated by chemicals;

(b) required to enter hazardous environments, for example, demolition sites and fire grounds, where potentially harmful chemicals may have been present; and,

(c) placed at risk of exposure to contaminated air, water, soil etc., as a result of any requisite sampling and monitoring procedures.

Inter-Agency Working

The most frequently stated lesson to be learned from the incidents reported was the need for improved inter-agency communication and collaboration. In particular, calls were made for the more effective and timely interchange of relevant information at and from the scene of an incident. Where achieved, it had been possible to effect appropriate mitigatory measures in advance of the escalation of any incident. Conversely, problems arose where information was not passed on, and local authority Environmental Health Departments found themselves compromised by their inability to respond effectively to community concerns.

Risk Assessment

From the comments received, local authority Environmental Health Departments clearly felt exposed by their inability to immediately access appropriate continuous monitoring equipment to assess possible health risks to the public who may have been exposed downwind of a fire, chemical spill or an airborne release. However, even if such a capability had been available, it is unlikely that any CEHO would have allowed a member of his/her staff to enter a potentially hazardous environment to monitor air quality. Decisions therefore need to be taken as to which authority/agency is best placed to undertake such monitoring, whether staff should be provided with personal protective equipment and/or would the use of environmental modelling and/or biological sampling represent more appropriate methods of evaluating exposure.

An issue that also came to prominence was the increasing pressure placed on local authority Environmental Health Departments to make objective assessments of risk in relation to civil claims by members of the public whose properties had been covered by dust or whose health had been allegedly affected by releases of, for example, hydrogen sulphide gas. Two of the main difficulties identified in drawing appropriate conclusions were (a) the general paucity of data available on the short and longer term health effects of exposure to chemicals; and (b) the lack of any information on typical background levels of chemicals in the environment. In relation to the latter, one option put forward was for the development of a database of ambient environmental concentrations of chemical pollutants, particularly around industrial processes.

Finally, calls were made for the development of risk assessment guidelines to support public health decision-making, both at the time of incidents, and in answering any such follow-up enquiries from members of the public.

Risk Communication

From the responses received, there was little doubt that dealing with the public's perception of risk was becoming an ever more difficult problem for the agencies / authorities involved in incident management. The importance of ensuring the regular provision of accurate, consistent and co-ordinated information was highlighted as critical, both in reassuring the public regarding the potential risks to their health, and in advising those most at risk of the actions they should take to minimise their personal exposure, for example, evacuate or shelter indoors.

Part of the problem was caused by journalists and television reporters who chose to highlight those aspects of an incident which were sensational and newsworthy rather than accurately communicate the risks, which were often negligible, to the public. However, where properly briefed, it was recognised that the media could fulfil an important role for the response agencies in maintaining information flow during crisis situations.

Additionally, in communicating with the public either directly or through the media, it was considered vital that the response agencies involved jointly designated an expert individual(s) as solely responsible for public / media relations; and that inter-agency consultation was required on the content of any press releases to eliminate potential confusion caused by the release of differing messages by individual authorities acting in isolation.

Follow-up

Epidemiological Follow-up

As emphasised in the literature review, incidents of toxic exposure present rare opportunities for investigation of the short and long-term health effects of chemicals. However, in only one of the 270 incidents reported by local authority Environmental Health Departments was any kind of formal epidemiological study undertaken. This followed a major explosion and fire at a South Wales factory in 1993, and involved no more than a retrospective study of symptom prevalence in a cohort of employees and emergency responders potentially exposed to the toxic effects of the chemicals released. The results proved inconclusive, but the ensuing discussion did highlight some of the difficulties faced by public health professionals in carrying out epidemiological studies following chemical incidents. These included:

a) problems in identifying exposed people (hampered by lack of information on the area covered by the smoke plume);

b) insufficient data on the chemicals stored at the factory (a definitive list of chemicals involved was not obtained until 2 weeks after the incident);

c) scantiness of information on the likely thermal decomposition and reaction products of the chemicals involved in the fire; and,

d) the lack of any objective measures of exposure at the scene of the incident (environmental monitoring equipment was not available), which precluded the possibility of determining any dose-response relationships.

Whilst it was evident, in relation to a number of the incidents reported, that local authority Environmental Health Departments had actively considered undertaking epidemiological studies (in collaboration with their respective health authorities), they had invariably been constrained by both the financial and organisational resources that would have needed to be made available. Criteria for determining the appropriateness and cost-benefit of conducting short and long term follow-up studies were required, as were model questionnaires and protocols to assist authorities in recording valid, reliable data. The division of responsibilities between local authorities and health authorities also needed careful consideration as part of the overall emergency planning process.

Population / Environmental Rehabilitation

In the rehabilitation phase, the aim must be to restore the affected areas to their pre-incident state. This includes not only the provision of social, economic and psychological support to the local population, but also rehabilitation of the environment. Based on the direct experiences of a number of the reporting officers, calls were made for the development of protocols and joint methods of working for dealing with rehabilitation issues in relation to:

- the disposal of oil contaminated beach materials;

- the safe handling and disposal of chemical drums washed up on beaches, illegally dumped or spilled in transport;

- the safe removal and disposal of damaged drums and residual chemicals involved in fires;

- the safe collection and disposal of clinical wastes including sharps; and

- preventing and mitigating the effects of fire-fighting water run-off into water courses and sewers.

Audit

Reference was also made to the importance of each response agency maintaining records of all events, decisions and actions taken by its staff, and the necessity for formal debriefing sessions, on both a single and multi-agency basis. These were considered important for a number of reasons:

a) to agree on appropriate adjustments to emergency plan(s) and procedures;

b) to provide the basis for recommendations on future prevention strategies and legislative changes; and

c) to allow the lessons learned from the incidents to be made more widely available for the benefit of those who might be called upon to respond to similar incidents in the future.

Conclusion

From the above appraisal, the views expressed by reporting officers at the one-day workshops, and the conclusions and recommendations made at the "toxicovigilance" conference, it was also felt that consideration should be given to the most effective way of providing additional advice and support to local authorities, health authorities and other agencies in Wales on a 24-hour, 365 day basis, in relation to the environmental and public health management of chemical incidents. One option put forward was for the establishment of a centralised advisory and support unit to complement the activities of the Welsh National Poisons Unit, which already provides advice to health professionals on medical management of casualties. Potential roles of such a unit might include:

a) development and maintenance of a national directory of information resources and expertise.

b) provision of a 24-hour advisory and consultancy service on the public health, environmental, chemical, medical, toxicological and epidemiological aspects of acute chemical incidents, including advice on immediate measures to protect local populations;

c) co-ordination of response to cross-boundary acute chemical incidents;

d) promotion of joint planning between local authorities, health authorities and other key players such as the emergency services, the Health and Safety Executive, and the Environment Agency;

e) development of best practice protocols, and provision of advice on their interpretation and application;

f) co-ordination of surveillance of health effects of chemicals in the environment, to include the longer term health effects of accidental releases of chemicals, and the incidence and possible health effects of ambient levels of acute chemical incidents;

g) collaborative working with other organisations in the UK and international centres of expertise;

h) pro-active identification of the needs of local authorities, health authorities and other agencies responding to acute chemical incidents in Wales;

i) promotion of programmes of training, education and research on a multi-disciplinary basis.

Evaluation of the AWEHSP

Introduction

In 1988, Thacker *et al.* proposed an evaluation method that could be applied to any system of epidmiological surveillance (Thacker *et al.* 1988). This was quickly adopted as best practice by the US Department of Health and Human Services (Centers for Disease Control 1988), and provides the basis for the following discussion and evaluation of the AWEHSP.

The AWEHSP was and still remains an unique, collaborative venture. It brought together central government, local government and academics with the common goals of better defining the size of the problem of acute chemical incidents within the principality of Wales, and of identifying the additional expertise and resources needed to support health and environment professionals in their future management of such incidents.

The primary question to be addressed in this section is whether or not the information provided by the project is useful. Has the system led to an improved understanding of acute chemical incidents in Wales? Were the original objectives met? Has the most effective use been made of public health resources? The AWEHSP is therefore reviewed with respect to its usefulness and cost, as well as on the basis of its quality. In assessing quality, the system is measured against each of the seven attributes formulated by Thacker *et al.,* that is, simplicity, flexibility, acceptability, sensitivity, specificity, representativeness and timeliness (Thacker *et al.* 1988).

Usefulness

The AWEHSP has demonstrated that a geographically defined, multi-agency surveillance system is feasible and useful in identifying high-risk locations and types of incidents, together with the chemicals most likely to be involved. Quantitative estimates are also now available of the morbidity and mortality experience of employees, emergency responders and the general public exposed to acute chemical incidents, and various expertise and resource issues have been highlighted for the future consideration of policy makers and public health professionals in Wales.

The surveillance system has therefore met its objectives. Nevertheless, in applying a more rigorous approach to defining usefulness, it is necessary to investigate further the impact of the project on policies and interventions (Thacker *et al.* 1988).

However, this is not an easy task. A large number of presentations were made and reports written on the project during its' period of operation. Quantifying the impact of the messages contained within these presentations and reports on policy makers, and on health and other professionals, is very difficult. For example, on 11 July 1994, a presentation was made to the Interdepartmental Group on Public Health (IDGPH) at the Department of Health, London. Chaired by the Chief Medical Officer for England, the IDGPH is acknowledged as an influential forum for debate on emerging public health issues in the UK. Although impossible to verify, the author is firmly of the opinion that the discussions held at this group catalysed many of the developments which will be covered in subsequent chapters.

In spite of this, it is possible to accentuate many of the positive uses that have been made of the surveillance data and the research that has been undertaken.

The AWEHSP has provided simple authoritative messages, such as most incidents involve the release of a single chemical. This is an useful finding, as it has been shown to be easier for the emergency services and health professionals to respond to such releases than to incidents which involve the release of many different chemicals, each having their own physico-chemical properties and each capable of reacting with one another to form substances which may have an even greater toxic potential than the original chemicals (Nantel 1992; Temple 1992; Sriramachari 1992). Additionally, the line-listing of the chemicals most commonly involved in incidents has already been used to prioritise the development of toxicological profiles for use by public health professionals in Wales.

The development of the AWEHSP also happened to coincide with the initiation of a programme of activity by the International Programme on Chemical Safety (IPCS) in the field of toxicovigilance. It was therefore agreed to jointly organise an international conference on health aspects of chemical incidents and their follow-up. The conference was held at Cardiff Institute of Higher Education from 1-3 April 1993, and experts invited from most regions of the world to present short discussion papers on the health sector response to major chemical incidents. A conference objective was "to provide guidance to assist the AWEHSP in meeting its objectives".

In this respect, the author gave a keynote presentation on the project. However, far from providing guidance to the project, one of the main conclusions drawn was the need to replicate the type of surveillance that was being undertaken in Wales on a global basis. IPCS therefore invited Cardiff Institute of Higher Education to become a WHO Collaborating Centre to act as an "International Clearing House for Major Chemical Incidents". The Collaborating Centre was formally launched in September 1995, and currently receives reports of major chemical incidents from eleven pilot countries, including Argentina, New Zealand and The Netherlands (a copy of the centre's "Terms of Reference" is included at Appendix 5.4).

The conference also highlighted a number of key areas where it was recommended that additional policy and technical guidance was needed in order to assist public health authorities in identifying, investigating and managing acute chemical incidents. Of particular interest is the fact that many of the conclusions and recommendations that were made (a copy of the full text is reproduced at Appendix 5.5) have subsequently been validated by the results of the AWEHSP.

Returning to Wales, the AWEHSP identified the need for further research into the development of risk assessment tools that would enable public health professionals to rapidly and objectively measure the severity of an acute chemical incident and its potential public health and environmental impact. The author therefore developed a "risk assessment scheme for the scaling of incidents" where the hazards presented by the chemical(s) released were related to the incident environment and the proximity of target populations (see Appendix 5.6), although this was never put into practice.

Such a scheme was seen as beneficial not only at the time of an incident, in terms of guiding mitigation activities, but also for surveillance purposes. By introducing a scoring system, analyses could be undertaken of incidents of similar severity, a practice which Lillibridge has since stated would be:

... invaluable for preparedness and prevention activities.

(Lillibridge 1997)

As will be evident from earlier sections of this Chapter, the results presented have been based on the combined data set from each reporting source. Although useful from the point of view of identifying general trends in the occurrence of acute chemical incidents in Wales, the results tell us very little about the relative risk posed by individual incidents. Consideration should therefore be given to the inclusion of such a risk assessment scheme within any future surveillance system.

Other research opportunities identified by the AWEHSP have included the need for a more detailed review of the problem of domestic carbon monoxide poisoning incidents within the principality. This was based on concerns expressed by the project steering group over the number of events recorded between 1993 and 1995. In this respect, the author was commissioned by the Chief Medical Officer for Wales in 1996 to undertake a short scoping study of the problem.

Although again difficult to quantify, in terms of usefulness, every opportunity was taken to promote the improved exchange of information between professionals within the various response agencies, via newsletters and workshops, on the most effective ways of handling particular incidents. The design of the forms also enabled reporting officers to identify areas where consideration needed to be given to the inter-agency development of guideline materials and best practice protocols.

Another important outcome of the project was the immediate integration of the research undertaken into the organisation and delivery of modules at undergraduate and postgraduate level on the public health management of acute chemical incidents. As early as October 1993, sufficient data had been collected and research undertaken to inform the development of a specialist module on the Masters in Public Health degree programme, offered by the University of Wales College of Medicine.

The AWEHSP has therefore demonstrated its usefulness from many different perspectives. It is probably fair to say that the data analyses conducted for this thesis could have been more extensive. However, it is the lessons learned in terms of additional expertise and resource requirements that will predominantly need to be taken forward in the development of the public health management model for dealing with acute chemical incidents in Wales.

Costs

The economic analysis of surveillance systems, in general, has received little methodological attention (Thacker *et al.* 1988). This may be because estimating the overall costs of a surveillance system is a complex process. The costs of administering the AWEHSP, that is, in terms of the personnel and financial resources expended in data collection, analysis, and dissemination, amounted to approximately £42,000 per annum over three years. However, this reflects only the "direct costs" and excludes estimates of the "indirect costs", such as pricing the time spent by reporting officers in the completion of forms every month.

To calculate a benefit / cost ratio is also very difficult, as many of the benefits involve unquantifiable value judgements, such as improved relations between response agencies. For the purposes of this discussion, it is therefore only possible to judge the "direct costs" against the objectives and usefulness of the surveillance system.

Evaluation of the Quality of the AWEHSP

Table 5.13 defines each of the seven attributes that are to be used to measure the quality of the surveillance system developed. However, each attribute should not be considered in isolation. They are all interdependent, and the improvement of one may improve or compromise another (Thacker *et al.* 1988). For example, efforts to increase the sensitivity of a system to detect more events may detract from its simplicity or timeliness (Centers for Disease Control 1988).

For ease of reference, the author has also incorporated within Table 5.13, details of the design features that were employed, from the outset of the AWEHSP, to meet each of the attributes.

Table 5.13 **Surveillance system attributes and the design features employed by the AWEHSP to ensure quality**

System Attributes	Definition (Centers for Disease Control 1988)	Design Features of AWEHSP
Simplicity	The simplicity of a surveillance system refers to both its structure and ease of operation. Surveillance systems should be as simple as possible while still meeting their objectives.	• manageable geographical area of coverage; • clearly stated objectives; • pragmatic "definition", with examples to guide interpretation; • clearly defined operational methods for data collection, analysis and dissemination; • clarity of questionnaire design and layout; • phased development of surveillance system; • dedicated full time member of staff.
Flexibility	A flexible surveillance system can adapt to changing information needs or operating conditions with little additional cost in time, personnel or allocated funds. Flexible systems can accommodate, for example, ... variations in reporting sources.	• system adaptable to incorporate new sources of data; • responsive to demands of reporting officers; • clarity of questionnaire design and layout; • ability to enhance data analysis and dissemination.
Acceptability	Acceptability reflects the willingness of individuals and organisations to participate in the surveillance system.	• establishment of project steering group to represent user interests; • regular consultation with reporting officers; • clearly defined system of reporting; • clarity of questionnaire design and layout; • little or no training requirement for reporting officers; • little or no extra burden of work for participating agencies; • regular feedback of data and other information; • data ownership and confidentiality issues defined and agreed; • project funding provided by user group.
Sensitivity	Sensitivity is defined as the ability of the surveillance system to detect true health events, that is, a measure of completeness of reporting.	• defined geographical area of coverage; • multi-agency reporting sources; • clear definition of a chemical incident; • active management of data collection by issue of monthly prompt and dispatch of reporting forms; • follow-up of media reports; • data validation routines.
Specificity	Specificity is a measure of the failure of the system to correctly classify the events under investigation.	• clear definition of a chemical incident; • verification of data with reporting sources.
Representativeness	A surveillance system that is representative accurately describes a) the occurrence of a health event over time and b) its distribution in the population by place and person	• defined geographical area of coverage; • multi-agency reporting sources; • sensitivity and specificity of system; • clarity of questionnaire design and layout; • data validation routines; • identification of other potential reporting sources.
Timeliness	Timeliness reflects the speed or delay between steps in a surveillance system	• active management of data collection by issue of monthly prompt and dispatch of reporting forms; • follow-up of late responders; • weekly data input and validation routines; • regular feedback of concerns to project steering group and at meetings of user groups; • establishment of data analysis routines and regular feedback of data and other information on the project.

Simplicity

Simplicity was very much the guiding principle in the design of the system. As the reporting of incidents from all sources was on a voluntary basis, the system had to be easy to understand, and a balance maintained between the system's needs for data of appropriate quality and the likely impact of the added burden of reporting on the work of local authority Environmental Health Departments and others. In the author's opinion, simplicity was largely achieved through the design features of the AWEHSP. At the annual one-day workshops, where reporting officers were given the opportunity to comment on the system, no criticisms were forthcoming and only minor amendments sought to the operational methods employed for data collection.

Problems were initially experienced in that over-emphasis was placed on the use of an electronic system for communications between the author and the reporting officers, including the return of completed questionnaires. However, it was soon recognised that very few of the officers had received any training in the use of the messaging system proposed. Accordingly, a paper system of communications was adopted for the three year duration of the project.

The principality of Wales was also a suitable size for the conduct of an active, geographically defined surveillance system. It was a manageable project for one full-time member of staff, and facilitated by the phased programme of implementation agreed by the project steering group.

Flexibility

The flexibility of the system originally developed with local authority Environmental Health Departments was clearly demonstrated by its ability to accommodate new reporting sources, that is, the Welsh National Poisons Unit and Gwent Fire Brigade. The introduction of these additional sources was also effected with the minimum of training requirements for reporting officers and without any additional funding.

Acceptability and Timeliness

It would be easy to state that each month a 100 per cent return rate was achieved from each reporting source, which was the case. However, there was considerable variability in the willingness of individual reporting officers to make returns. From the author's perspective, there were individuals who questioned the benefits both to them and their authorities of participating in the system. Although no quantitative assessment was undertaken, the priority with which individual reporting officers viewed the project was manifested by delays in the return of forms, the rapid completion of nil returns when pressurised by the author, and the lack of completeness of those reporting forms returned on incidents. The latter was a particular problem at the outset of the project, with reporting officers simply providing a summary of an incident on the front sheet and leaving the remainder of the reporting form blank.

Such issues were addressed through the design features listed in Table 5.13, but most effective was the opportunity provided to the author every other month to provide a progress report on the project to the All Wales Chief Environmental Health Officers Panel. This ensured that any difficulties were addressed to the operational "heads" of departments, who would jointly agree an appropriate course of action to effect improved timeliness and completion of returns.

Sensitivity and Specificity

The benefits of a multi-agency surveillance system were clearly demonstrated with respect to sensitivity, with little overlap in the incidents reported by the various sources. However, this suggests that the sensitivity of the system would only have been further enhanced by extension of reporting to other sources in Wales.

The introduction of media vigilance as a check on reporting sources was also seen to effect improved sensitivity of the system. However, there were limitations to the project. Although difficult to quantify, it is well recognised that not all of the incidents that occurred in Wales between 1993 and 1995 were reported to the project. Any surveillance system must question why small, rural authorities were reporting up to 15 incidents a year, and large, urban authorities only 3. In the author's opinion, there were two reasons:(a) the large, urban authorities did not perceive the project to be as beneficial to them, because they had the resources and the need to employ more expert staff in-house to deal with acute chemical incidents (hence there was an acceptability problem), and (b) the same authorities appeared to operate on the basis of a higher threshold level for the reporting of incidents than the small, rural authorities.

The latter point is also worthy of consideration in assessing the specificity of the system. There were problems initially with the definition being too permissive, with outbreaks of infectious diseases being reported. However, attempts were made to address these issues through personal meetings with each reporting officer to discuss the definition of an incident, and to place it within the context of possible scenarios that might be anticipated to arise within the geographical areas of each authority.

Representativeness

The representativeness of the system was also open to question. As stated above, there was evidence of reporting biases, dependent on the enthusiasm of particular agencies and the way staff chose to interpret the definition of an incident. It was also difficult to assess the reliability and validity of the responses received, for example, the results presented on numbers of people exposed and with symptoms are crude estimates, as post-incident health investigations involving accident and emergency departments, general practitioners and / or health authorities were rarely undertaken.

Discussion

The AWEHSP, based on the reporting systems developed with local authority Environmental Health Departments and with other agencies in Wales, certainly met its objectives, and has also demonstrated effectively the utility of collecting, collating and analysing data on acute chemical incidents. However, it is also important to consider the lessons that can be learned from the evaluation of the system. In particular, the concerns raised in relation to acceptability and timeliness, sensitivity and specificity, and representativeness will need to be carefully considered in the design and development of any future surveillance systems.

Chapter 6 - Model Development

Introduction

This Chapter aims to progress the lessons learned from the All Wales Environmental Health Surveillance Project (AWEHSP) in developing a public health management model for dealing with acute chemical incidents in Wales. As any such model, to be effective, must be integrated into the existing system of control set out in Chapter 4, the author's original intention was to have carried out a survey of key personnel of agencies participating within the AWEHSP. The principal aims were to have been (a) to ascertain the perceptions and attitudes of the interviewees and their respective organisations, with regard to the role of public health in the management of acute chemical incidents; and (b) to utilise the results so obtained in the design and development of a public health management model for acute chemical incidents in Wales. However, the success of the AWEHSP opened up better opportunities to fulfil this component of the author's research. The development of the model has therefore followed an evolutionary locus which could not have been anticipated at the outset. A major factor in this process has been the politics of the NHS, which will form the first part of this Chapter. There then follows a series of stages, which take the author's research from Wales to the South and West of England, to the conduct of a national research project (Study of Activity on Public Health Effects of Environmental Chemicals) and participation in roundtable discussions.

The Politics of the National Health Service

The term "public health policy" may be viewed in different ways. It may be limited to authoritative statements of intent by government or may arise as a consequence of the actions taken by individuals in the process of implementation, that is, what policy is can only be seen in terms of outcomes (Barrett and Fudge 1981). As will be evident from the following discussions, it is the interpretations and actions of the lower-level actors, which include the author, that have largely determined the model that has been developed. The role of government, which at the time was Conservative, was to ensure that the market model of health service provision was upheld. This, in essence, was its statement of intent.

A market model assumes that health services are a product like any other. Where a demand exists, then market forces will supply the services required for a price. Suppliers will advertise their wares, while competition ensures a price which guarantees that consumer preferences are met (Allsop 1995). This contrasts with the two traditional models of health service provision: the professional model and the bureaucratic model, which assume that health services are too important and knowledge too specialised to be treated as a market good. The professional model places authority with the expert. Because it is based on technical and expert knowledge, those who need services must be protected from unqualified practitioners. The approach is therefore essentially paternalistic. In the bureaucratic model, the state assumes the role of determining health policy and becomes involved in distribution issues such as: ensuring access to services for all, the allocation of resources, the management of services and the ordering of priorities.

From its establishment in 1948 to the late 1980s, the NHS was a prime example of a centrally planned and funded public health service (Ranade 1994). The dominant model was the bureaucratic model. Within this model, however, considerable autonomy was also given to the professional providers (the professional model), in what has been described as a corporatist style of health politics (Cawson 1982; Ham and Hill 1993), and a command and control economy (Allsop 1995). Like most command and control economies, the NHS was criticised for its rigidity, its inefficiency and its meanness. Problems were also manifest in achieving value for money, and in implementing change where it did not coincide with the concerns of professional medical interests (Allsop 1995). Consequently, in 1989, this all changed with the issue of the White Paper "Working for Patients" (Secretary of State for Health 1989), which pioneered the market model of organising and delivering health services. Enacted by the NHS and Community Care Act of 1990, a structure was created of buyers and sellers by separating responsibility for the purchase of health services from its provision, and allowing limited competition for business between providers, e.g. hospitals within strict regulatory guidelines (Ranade 1994). As will be shown, the marketplace has proven to be an important factor in guiding the work undertaken.

Another aspect of the politics of the NHS which has impacted on the development of the model has been the interest groups involved. In this respect, Alford has suggested that:

> ... interests in health care can be classified into three major groupings: the professional monopolisers, the corporate rationalisers and the community interest.
>
> (Alford 1975)

The dominant grouping are the professional monopolisers which, in the case of acute chemical incidents in the UK, comprise a small number of doctors and scientists, whose expertise of the subject area means that they can sell their skills and knowledge at a price. In contrast, the second grouping, the corporate rationalisers, include the politicians and administrators at central (Welsh Office) and local level whose primary objectives are to achieve greater coordination and integration in the planning and delivery of health services. Their interests lie in making the best use of the resources available. Finally, the third grouping represents the cluster of organisations which seek to introduce a different set of priorities. They attempt to influence health policy through, for example, lobbying both the professional monopolisers and the corporate rationalisers. As with the marketplace, the presence and role of all three groupings will become increasingly evident in the following discussions.

From Wales to the South and West of England

In May 1995, the author was invited by the Regional Director of Public Health (RDPH), NHS (South and West) Region, to present a paper on the AWEHSP at a meeting in Bristol. This was partly as a result of the findings of a survey conducted by Gunnell of the 21 DHAs within the Region (Gunnell 1993). The survey found that 15 of the 17 DHAs that had replied possessed no specific policies for handling acute chemical incidents, prompting concerns about the ability of the public health medicine profession to be seen as competent to manage such events. In attendance at the meeting were the RDPH and other representatives of the NHS Region, two local authority Directors of Environmental Health, plus officials from Welsh Office and the Department of Health. The outcome of the meeting was a recommendation to replicate the AWEHSP in the NHS (South and West) Region. This was considered beneficial to both sides. From the author's perspective, the ecology of the South and West was essentially the same as that of Wales (major conurbations, large tracts of agricultural land and an extensive coastline). Replication therefore provided an ideal opportunity to validate the findings of the AWEHSP.

At the meeting, the author also placed particular emphasis on the need for the proposed South and West Environmental Health Surveillance Project (SWEHSP) to be a collaborative venture between local authority Environmental Health Departments and health authority Departments of Public Health Medicine. Accordingly, the author was mandated to organise a meeting in Stroud, Gloucestershire in October 1995, to which the CEHOs of 16 representative local authorities, and the DsPH and CsCDC of all 12 health authorities in the Region were to be invited. A copy of the agenda for the meeting is attached at Appendix 6.1, together with a short discussion paper prepared by the author on the potential benefits of the SWEHSP to the Region.

From the round table discussions that followed the various presentations, it however became apparent that whilst surveillance was recognised as important, it was a 24 hour support and advisory service that was required, along the same lines as that described in the last Chapter. Those attending the meeting therefore agreed to establish a "Project Advisory Group", under the chairmanship of the author, comprising representation from the Regional Office, and an equal number of CEHOs and DsPH. Pump-priming for the venture was provided by the Regional Office.

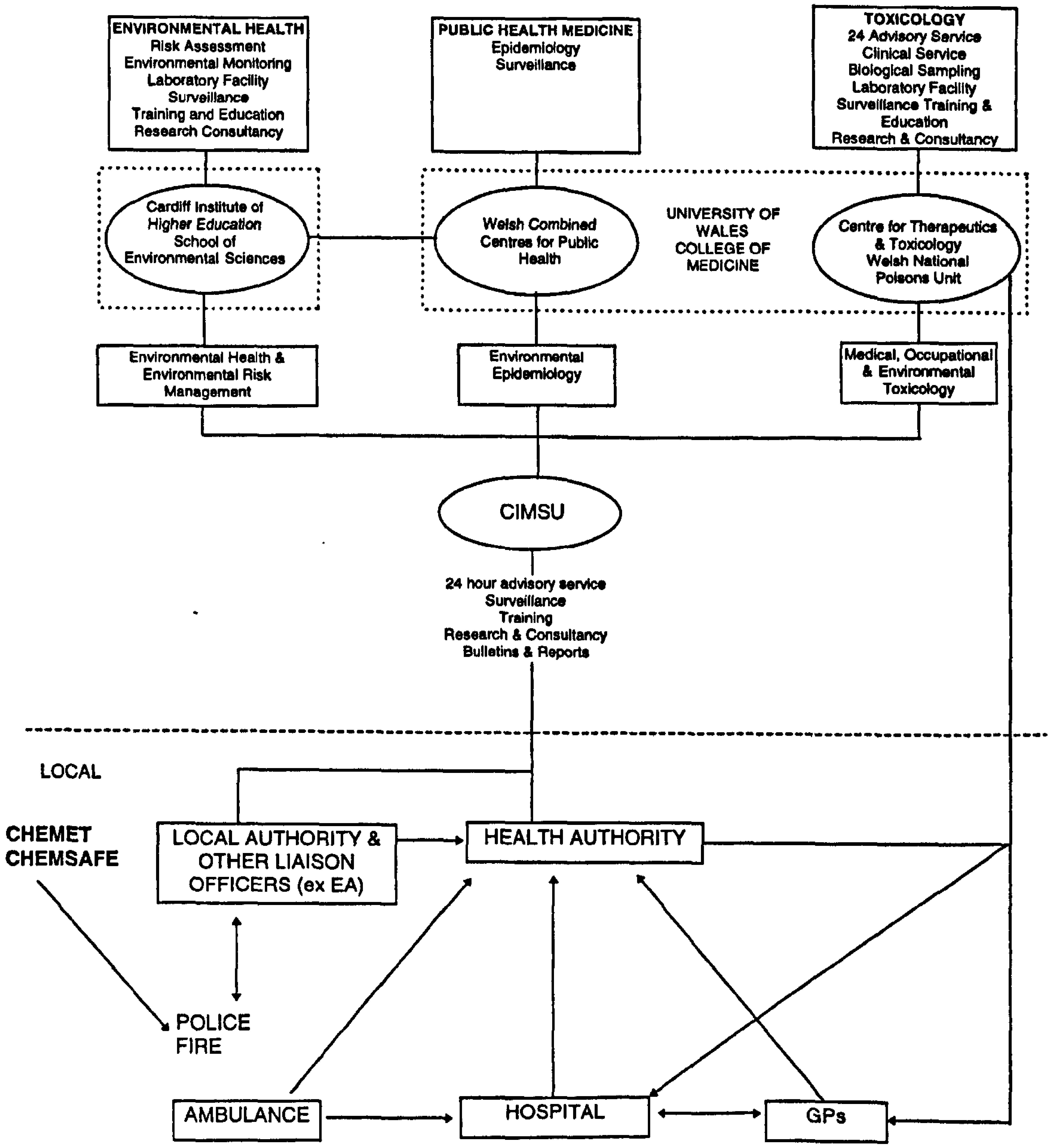
Development of a 24 hour Support and Advisory Unit for Wales and the NHS (South and West) Region

The Project Advisory Group for the SWEHSP met for the first time on 11 December 1995. At the meeting, the author tabled a draft "Service Delivery Plan" for the provision of fast response, multi-skilled advisory services on both a 9-5 weekday basis and a 24-hour, 365 day basis. In delivering the plan, the intention was to pool the expertise and resources of three existing centres: (a) the Welsh Combined Centres for Public Health of the University of Wales College of Medicine in applied public health medicine and environmental epidemiology; (b) the Toxicology and Therapeutics Centre of the University of Wales College of Medicine in medical, occupational and environmental toxicology; and, (c) the School of Environmental Sciences at the then Cardiff Institute of Higher Education in environmental health and environmental risk management. A schematic of the model developed, incorporating details of the expert resource available within each Centre is provided in Figure 6.1. A copy of the draft "Service Delivery Plan" is reproduced at Appendix 6.2.

The service, named the Chemical Incident Management Support Unit (CIMSU), was aimed at both local and health authorities in the NHS (South and West) Region, and likewise at similar authorities in Wales, following presentations by the author at meetings of the Welsh Collaboration for Health and Environment[1]

[1] The Welsh Collaboration comprises senior professional representatives from all Environmental Health and Public Health Medicine Departments in Wales, Health Promotion Wales and the Welsh Combined Centres for Public Health. The purpose of the collaboration is to provide a network to encourage the free-flow of information between relevant health professionals.

Figure 6.1 Model for delivery of a comprehensive multi-skilled acute chemical incident support services to health and local authorities in Wales



Notes: Cardiff Institute of Higher Education became University of Wales Institute, Cardiff in April 1996

(2 February 1996) and the All Wales Chief Environmental Health Officers Panel (26 February 1996). These authorities were targeted not only because they had asked for such a service, but also because it was perceived as politically acceptable for CIMSU to provide services to the NHS (South and West) Region. The Welsh National Poisons Unit, one of the seven centres of the UK National Poisons Information Service and an integral part of the Toxicology and Therapeutics Centre, was already contracted by Welsh Office and the Department of Health respectively to provide poisons information services to both Wales and the NHS (South and West) Region.

Although the culture in the NHS was, by early 1996, one of commissioning of services, it was never the author's intention to enter a competitive marketplace environment. The creation of CIMSU was perceived as a development project to foster partnerships with and between local and health authorities (and also the emergency services and other response agencies), in the common interests of securing improvements in the public health management of acute chemical incidents. In the absence of any centralised source of funding, it was however necessary to ask authorities to contribute to the development of the Unit.

The development of CIMSU also enabled HAs in Wales and the NHS (South and West) Region to meet the responsibilities placed upon them by national guidance. In both Welsh Health Circular (93)61 and Health Service Guidelines HSG (93)38 (health service arrangements for dealing with chemical accidents - see Chapter 4), each HA was required to ensure access to:

> ... the necessary advice and expertise concerning public health hazards arising from chemical accidents.
>
> (Welsh Office 1993; Department of Health 1993)

However, in meeting the demands of the client, and offering services at a price, there was no escaping entry into the market model of health service provision.

Development of other 24 - hour Support and Advisory Units in England

At the same time as CIMSU was being developed, similar services were also evolving in other parts of England. In the West Midlands (NHS) Region, the clinical, toxicological and chemical expertise of the West Midlands Poisons Unit (part of the NPIS) was being brought together with the environmental, public health and epidemiological expertise of the Institute of Public and Environmental Health, University of Birmingham to form the Centre for Chemical Incidents (Vale 1996). At the Medical Toxicology Unit at Guy's and St Thomas Hospital, London (again part of the NPIS), a "Chemical Incidents Research" programme had been in existence since 1990 (Medical Toxicology Unit 1995). This became the Chemical Incident Response Service, London in January 1996. Finally, in Newcastle, the University Medical School's Department of Occupational and Environmental Medicine was developing a service (Chemical Incident Service, Newcastle) for health authorities located in the Northern and Yorkshire (NHS) Region (Blain 1996). In terms of the politics of the NHS, the individuals behind these units might therefore be described as the professional monopolisers.

The Position of Central Government

Of particular relevance in linking these developments to national roles and responsibilities, was the separate approach taken by the Scottish Office Department of Health. In 1989, central funding had been provided by the NHS in Scotland to resource the Environmental Health (Scotland) Unit, as a sister unit to the Communicable Disease (Scotland) Unit, which had been established in the late 1960s. The functions of the Unit were:

> (a) to be a national centre for expert advice on all matters of environmental health ... available to central government, local government, research organisations, and the public, free of charge;
>
> (b) to undertake environmental investigations on its own initiative, or when requested by an organisation;
>
> (c) to initiate surveillance and research programmes on important environmental health issues; and
>
> (d) to develop graduate and post-graduate training in environmental health for medical, veterinary, environmental health, nursing and other health personnel.
>
> (Forbes 1993)

In being funded by the NHS, the unit was able to give independent and unbiased advice to both central and local government, a capability that was effectively demonstrated in the handling of the public health aspects of the Braer disaster (Campbell *et al.* 1993). In 1994, the two units merged to form the Scottish Centre for Infection and Environmental Health (SCIEH).

By way of contrast, under the system that was evolving in Wales and England, the corporate rationalisers at Welsh Office and the Department of Health respectively soon realised that they might themselves not have access to the advice provided by CIMSU and the other units to health authorities. There was also no readily identifiable national centre in existence which could coordinate the activities of the Units, for example, in relation to surveillance, training and the handling of cross-regional incidents.

In parallel with these developments, references were also increasingly being made within the public health literature to the need for the development of a national chemical incident surveillance - resource centre - a so-called Communicable Disease Surveillance Centre (CDSC) for toxicological hazards to health (Baxter *et al.* 1995). Ayres went further in suggesting that such a centre might have the following functions:

1. to monitor the frequency and severity of incidents;
2. to act as an information and skill resource centre giving information and loaning expertise, particularly at the time of the disaster, but also giving advice on continuing surveillance requirements;
3. to define the training needs for public health doctors and members of other agencies who are responsible for managing disasters when they occur;
4. to support the planning process in all establishments where there is a need;
5. to promote the development of links nationally between agencies ...; for example, toxicology units, occupational health departments, epidemiology units etc.;
6. to assist the International Programme on Chemical Safety to promote international links to increase the amount of expert knowledge available, and improve access to that knowledge.

(Ayres 1995)

Study of Activity on Public Health Effects of Environmental Chemicals

Introduction

In January 1996, the Department of Health therefore concluded that there was a need to commission a study to review the scope and targeting of the activities which it was currently supporting on the effects of environmental chemicals on human health. This included incidents of acute exposure to relatively high levels of hazardous or potentially hazardous chemicals. The aims of the study were:

a) To determine the availability of expertise and resources which could be utilised to support the needs of the Department of Health and the National Health Service for information and advice in fulfilling their recognised roles in responding to chemical accidents;

b) To identify sources of expertise which could be utilised to assist the Department of Health in its functions of providing advice to various parties on the relationship between ill-health and environmental chemicals;

c) To augment and support the above, through the identification of a network of research centres, able to keep the Department of Health abreast of potential hazards to human health arising from exposure to environmental chemicals.

(Department of Health 1996)

Accordingly, tenders were invited by the Department of Health, by way of a letter sent to selected UK organisations on 8 January 1996, to:

(a) undertake a short study to map out existing activity by the Department and other bodies; and

(b) identify gaps which the Department should consider filling.

(Department of Health 1996)

The author submitted an application to undertake the study, under the auspices of the Welsh Combined Centres for Public Health, and was invited to do so by the Department of Health on 29 January 1996. Although it was recognised that the study centred primarily on England, the intended outcome was essentially the same, that is, to develop a public health management model for acute chemical incidents. As such incidents have no respect for boundaries, it was considered unlikely that the Welsh Office Public Health Unit would agree to a separate model for the principality from that proposed for England. This was confirmed by Welsh Office's endorsement of the study (Whinney 1996). There was therefore very little point in the author undertaking the planned structured interviews of key personnel of agencies in Wales, when there would have been no possibility of testing the resultant model in any practical setting.

Having had the opportunity to review the accompanying papers to the letter, the author set the following objectives for the study:

(a) to conduct structured interviews with representatives of key UK organisations active in the area of health effects of environmental chemicals, including government departments, government funded bodies, university departments, professional associations and the private sector;

(b) to establish the present range and scale of activities of these organisations in relation to the perceived gaps in current provision;

(c) To collate the information and prepare a report for the Department of Health summarising which organisations are active, the scope and scale of their activity and how their respective activities overlap; and

(d) To identify and report where the Department of Health could make use of existing activity to meet the needs for itself and / or for the NHS and where gaps remain which need to be filled.

Method

Study Design

The Department of Health were keen for the study to be completed by mid-March 1996. The planning, reading, design and exploratory pilot work therefore had to be compressed into a two-week period. In this respect, Oppenheim's five stage approach to decision-making in relation to study design provided a useful guide to best practice (Oppenheim 1992).

A. Method of data collection

A standardised, formal interview approach was chosen as the method of data collection for the study. The advantages of using interviewers, as opposed to postal questionnaires, were (a) improved response rates and consequently less biases in the sample of respondents, (b) the capacity to provide explanations of the purpose of the study more convincingly than could be achieved by a covering letter, (c) the ability to maintain better control over the order or sequence in which the questions were answered, and (d) the potential for personal insights to be obtained of the perceived gaps in current provision with respect to the study's areas of interest.

B. Method of approach to respondents

Oppenheim found that:

> ... the most important determinant both of response rate and of the quality of the responses is the subject's motivation.
>
> (Oppenheim 1992)

To gain the respondents' cooperation, a letter was therefore sent in advance of the study, which (a) informed each respondent that an approach would soon be made to set a mutually convenient date and time for their interview; (b) made reference to the fact that the study was sponsored by the Department of Health (which subsequently proved to be a powerful motivator); and (c) gave assurances of confidentiality and anonymity in respect of the data provided by each respondent. The issue of dealing with non-responders did not arise, as all intended respondents participated in the study.

C. The build-up of question modules

A questionnaire is essentially a tool for data collection; its function is measurement. The detailed specification of measurement aims must therefore be precisely and logically related to the aims and objectives of the study and the reference framework adopted (Oppenheim 1992). In this respect, the author used the internationally evaluated guidance materials on the public health sector role in chemical incident preparedness, response and follow-up, which had been prepared in consultation with the International Programme on Chemical Safety, as the reference framework for the questionnaire design.

The result was the development of a series of question modules, each concerned with a different variable, for example, surveillance of incidents, emergency planning and risk assessment. These modules were then placed in order, having regard to the internal logic of the inquiry and the likely reactions of respondents.

D. Order of questions within modules

The so-called "funnel" approach (Oppenheim 1992), preceded by various "filter" questions, was employed in ordering the questions within each of the modules. Accordingly, many of the modules started with a filter question, aimed at excluding respondents from a particular question sequence if those questions were irrelevant to them. A broad question was then included, followed by a progressive narrowing down of the scope of the questions until some very specific points were reached.

E. Question types

Open questions were primarily chosen for inclusion within the questionnaire. This was to give free expression and spontaneity to respondents in their replies, which was seen as particularly important, in light of the need to identify gaps in current provision.

The end result of this five-stage process is the questionnaire shown at Appendix 6.3. As will be seen, the questionnaire is divided into four sections, and a number of sub-sections. Section A asks about the scope and range of activity of each organisation in relation to chemical incidents. Each sub-section or variable then follows a set pattern of questioning, aimed at identifying whether an organisation has received requests for assistance to provide a particular service, for example, risk assessment expertise, and from whom; the capability of that organisation to respond and on what basis; the number of years of experience possessed; the means of financing such an involvement; and, any proposals for the future. Sections B and C were designed to obtain qualitative data on the surveillance / research activities of the organisations interviewed, in relation to both the systematic, ongoing collection of data on the health effects of "routine" levels of pollution, and specific studies investigating the human toxicology of environmental chemicals. Finally, Section D covers the gaps perceived by interviewees in organisational response to the public health effects of environmental chemicals.

Management of the Study

As with the AWEHSP, the author set up a small steering group to provide direction to the work being undertaken. The steering group met on three occasions during the course of the study, as shown in Table 6.1 below. An ongoing dialogue was, however, maintained between the author and individual members of the steering group during the writing-up phase of the study.

<u>The Interview Process</u>

In view of the large number of organisations to be interviewed over such a short time period, the author also engaged the services of two other colleagues with experience both in the conduct of interviews and the management of the public health aspects of chemical incidents: Mrs. Sarah Jones, Senior Lecturer in Environmental Health and Environmental Risk Management at the then Cardiff Institute of Higher Education and Dr. Jane Layzell, Lecturer in Public Health Medicine at the University of Wales College of Medicine.

Although unachievable in practice, interviewers are bound by the requirement of *stimulus equivalence,* that is, that every respondent should understand a given question in the same way as every other respondent (Oppenheim 1992). The author therefore met with the two other interviewers on several occasions, in advance of conducting any interviews, to discuss the ordering and phrasing of questions, the use of open-ended probes, and how to deal with "problem respondents". Given the constraints of time imposed by the Department of Health, it was only possible to pilot the questionnaire in two interviews. Both were followed by further discussion, leading to changes in the design of the questionnaire and the preparation of an interview schedule to promote precision and conformity.

In discussion with the Department of Health, a total of 41 organisations were selected for interview. The author conducted 13 interviews, with the remaining 28 split equally between the two other interviewers. Face-to-face interviews were conducted with representatives of 37 of the organisations, and telephone interviews with the other 4 organisations.

Table 6.1 Study Timetable

Description	Timetable
Notification received from Department of Health of "Approval of Tender"	29 January 1996
Formal meeting with Department of Health to agree study protocol, to include organisations to be contacted, questionnaire design etc.	6 February 1996
Steering group meeting	13 February 1996
Author meets with co-interviewers to finalise questionnaire design, allocation of responsibilities, methods of working etc.	13 February 1996
Appointments made with key personnel of all organisations to be interviewed	13 - 15 February 1996
Pilot study completed, involving administration of questionnaire to key personnel at the Welsh National Poisons Unit and Welsh Office	15 and 19 February 1996
Steering group meeting	19 February 1996
Author meets with co-interviewers to review progress, evaluate pilot study and develop standardised interview protocol	19 February 1996
Formal meeting with Department of Health, including administration of questionnaire and full debrief on progress made	21 February 1996
Structured interviews conducted with key personnel of all organisations	21 February 1996 to 8 March 1996
Steering group meeting	8 March 1996
Author meets with co-interviewers to review progress and discuss preparation of final report	8 March 1996
Data processing	11 - 13 March 1996
Formal meeting with Department of Health to discuss preliminary findings of study	13 March 1996
Author writes final report	14 March - 30 April 1996
Submission of report to Department of Health	10 May 1996

Data Processing and Information Evaluation

Although easy to ask, the answers to open questions are often difficult to analyse. As a rule, a classification process must therefore be employed, known as coding (Oppenheim 1992). The questionnaire design therefore included some scope for field coding, where the interviewers were able to code answers on the spot by ticking or circling one or more categories of possible response.

For the most part, however, the responses were recorded in writing and coded back at the office. The coding frame employed was again based on the internationally-evaluated guidance materials on the public health sector role in chemical incident preparedness, response and follow-up. To check for accuracy, a summary of the coded information was prepared and sent to each organisation for comment. Where necessary, appropriate amendments were then made to the original data record.

The Statistical Package for the Social Services (SPSS) for Windows Version 6 was used for some processing and analysis, but in that the data collected from Sections A, B and C of the questionnaire was mainly qualitative in nature, the results were summarised in a series of tables, in accordance with the coding frame. A different approach was taken for Section D, as a number of the representatives interviewed did not wish their views to be attributable, as they were not necessarily the same as those held by the organisations on whose behalf they were being interviewed. The results for Section D are therefore anonymised, and presented on the basis of the combined data set from the organisations interviewed.

Results

The results presented below relate only to the responses received in relation to questions raised under Sections A and D of the questionnaire, that is, those applicable to incidents of acute exposure to relatively high levels of hazardous or potentially hazardous chemicals. The results from Sections B and C of the questionnaire, which relate primarily to "surveillance of health effects of "routine" levels of chemical pollution and supporting baseline information" fall outwith the remit of this dissertation and are therefore not presented.

<u>*Section A - Chemical Incidents*</u>

<u>General</u>

Of the 41 organisations interviewed, only three considered that they had <u>no</u> role to play in the response to chemical incidents. Appendix 6.4 provides a summary of the activities of each of the 41 organisations interviewed. "Activity" was carefully defined in terms of an organisation's experience of that role in an incident, as opposed to a statement that, although having no experience, it would have the capability to accomplish it.

<u>Specific</u>

The tables contained within Appendix 6.5 provide a detailed analysis and breakdown of the specific activities of the organisations interviewed, both in relation to the coding frame and the geographical area covered by their respective operations in the United Kingdom.

Registration of Sites / Carriers

The registration of sites was undertaken by 9 organisations. However, only two were mandated to do so by legislation (both government departments). In Wales and the NHS (South and West) Region, the NHS (West Midlands) Region and the NHS (Northern and Yorkshire) Region, a government-funded body and two university departments respectively were in the process of independently developing inventories of major hazard sites. The remaining 4 organisations comprised a government-funded body, a professional body, a private sector organisation and a centre of the NPIS.

Surveillance

Although 16 organisations reported undertaking surveillance of chemical incidents, only 4 of the systems could be said to truly meet the definition, as set out in Chapter 3. There were clear similarities between the three systems already in existence, in that the Department of Environmental Health and Institute of Occupational Health at the University of Birmingham, and SCIEH had both modelled their respective surveillance activities on the AWEHSP at WCCPH. The fourth system was in the process of being piloted by the WHO Collaborating Centre at WCCPH and was again founded on the AWEHSP. The remainder comprised ad hoc systems of incident recording, based on statutory notifications to government departments, voluntary reporting systems, analysis of enquiries and vigilance of press cuttings.

Environmental Monitoring and Modelling

Eighteen organisations stated that they received requests for assistance to undertake environmental monitoring following chemical incidents. Nine of the organisations were capable of deploying staff to the scene of an incident to undertake monitoring, but only three on a 24 hour, 365 day basis - a government department, a government-funded body and a private sector organisation. Of the remaining 9 organisations who received requests, 5 had access to the resources of other agencies on a contract basis, whilst 4 provided advice only on the nature and extent of the monitoring to be undertaken.

Twelve organisations were involved, to varying degrees, in the modelling of potential population exposures to airborne releases and / or chemical spills into watercourses. Only 3 organisations, however, had any experience of modelling at the time of an incident, namely the Ministry of Agriculture, Fisheries and Food (MAFF), the Marine Pollution Control Unit and the Water Research Centre. A further three organisations, two of whom had access to Geographical Information Systems (GIS), possessed the capability to undertake modelling. The remainder were either currently in the process of developing a modelling capability (N=3) or were involved primarily in a research capacity in initiating, commissioning and developing the actual models (N=3).

Biological Sampling

Fourteen organisations reported that they received requests for assistance in undertaking biological sampling of persons exposed following chemical incidents. However, only 6 (primarily university departments and government-funded bodies) had the capability to deploy staff to the scene of an incident. Of the remaining eight organisations, 3 held contracts with other agencies to conduct biological sampling on their behalf, whilst 5 provided advice only on the nature and extent of the sampling to be undertaken.

Analytical Services

Eleven organisations operated laboratory facilities capable of undertaking the rapid analysis of environmental and biological samples taken pursuant to chemical incidents. These included the Health and Safety Laboratory (part of HSE), the Laboratory of the Government Chemist and the Water Research Centre (both private sector). A further four organisations reported receiving requests to provide analytical services. All relied on the resources of other agencies to fulfill their obligations.

Emergency Preparedness / Planning

Twenty-eight organisations, comprising all sectors, reported receiving requests for assistance in the development of contingency plans. The main sources of such requests were HAs (N=19) and local authorities (N=15), followed by Regional Offices of the NHS (N=10). The remainder included emergency services, public utilities, industry and government departments.

The Department of Health, NHS Executive, Welsh Office, Scottish Office Department of Health and Department of Health and Social Services, Northern Ireland all confirmed that they had issued guidance to HAs within their respective territories in the past three years on "health service arrangements for dealing with chemical accidents". The Health and Safety Executive had also issued guidance to local authorities and industry in interpreting the emergency planning requirements of the CIMAH regulations (see Chapter 4). Other guidance comprised mainly that issued by professional bodies, such as the Chartered Institute of Environmental Health and the Chemical Industries Association to their constituent members.

Fifteen organisations stated that they regularly provided technical advice and assistance to HAs and local authorities on matters pertaining to emergency planning. These included all four support and advisory units, plus SCIEH. Fourteen of the organisations appeared as contact points in contingency plans (predominantly government departments and government-funded bodies), and 8 regularly participated in simulation exercises and / or incident debriefings. These included private sector organisations, such as the National Chemical Emergency Centre and the Water Research Centre. Two organisations provided training in emergency planning, namely the Emergency Planning College and the Marine Pollution Control Unit. The latter organisation is responsible for the development and maintenance of the national contingency plan for dealing with incidents of pollution from shipping and offshore installations with the potential to threaten UK interests.

Risk Assessment

Twenty-seven organisations reported receiving requests for assistance in assessing risks to human health following chemical incidents. Twenty-one of the organisations possessed the necessary capability to provide assistance with such assessments, and in 17 cases, support was potentially available on a 24 hour, 365 day basis. Seven of the organisations also had the capability to deploy staff to the scene of the incident, if required.

Of the six other organisations, 2 were experienced in undertaking assessments of risk to health arising from chronic exposure situations, but not specifically in relation to chemical incidents; one, a professional body, provided general advice on risk assessment methodologies only, whilst the three remaining organisations perceived their role as facilitating contact, on behalf of enquirers, with more appropriate sources of information.

Risk Management

The receipt of requests for assistance in managing the risks to human health presented by chemical incidents was reported by 24 of the organisations interviewed. Twelve possessed an in-house capability to provide expert advice and information on the risk management techniques to be adopted in such incidents, and 5 were also able to deploy staff to the scene of the incident.

Two organisations, namely the Laboratory of the Government Chemist (land remediation works) and the Marine Pollution Control Unit (counter-pollution measures at sea) were experienced in undertaking risk mitigation / mediation steps at the incident scene, whilst five organisations (principally the National Poisons Information Service) possessed the necessary treatment facilities for the provision of specialist clinical care to patients exposed to chemicals. Four of the 5 latter organisations also acted as administration centres for the dispatch of antidotes to Hospital Departments.

The Government Departments interviewed considered their roles to be informing and co-ordinating the policy and strategy development process for managing the public health aspects of chemical incidents, of enforcing legal restrictions (for example, MAFF in relation to the Food and

Environmental Protection Act 1985) and of facilitating access to other sources of advice and assistance (for example, HAGCCI).

Risk Communication

Twenty-six organisations reported that they received requests for assistance in communicating risk to the public/media following chemical incidents. Most (N=17) provided advice only, leaving communication to members of the local response teams. All four support and advisory units offered help in the preparation of press statements, but only one indicated that they were prepared to take part in the risk communication process.

Eight organisations had direct experience of communicating risk following such incidents. These were primarily Government Departments, with dedicated media liaison officers, who were also responsible for preparing briefings for Ministers and senior government officials, and answering parliamentary questions. Additionally, the four Health Departments all considered it part of their brief to promote consistency in the messages issued by the NHS and the other local response agencies/authorities.

Two organisations, both University Departments, stated that they were currently conducting research into the impact of information campaigns on public perception and knowledge, the results of which might usefully be applied in improving practices of risk communication following chemical incidents. Finally, the Chemical Industries Association had produced general guidance for its member companies on approaches to be taken in communicating risk to the media and/or the public.

Epidemiological Follow-up

Although 16 organisations reported that they received requests to undertake or participate in epidemiological studies of persons exposed following chemical incidents, only 7 of those interviewed provided any real evidence of experience. These included the Health and Safety Executive, the Scottish Centre for Infection and Environmental Health, the South East Institute of Public Health and the Welsh Combined Centres for Public Health. The other nine organisations stated that, whilst they had not been specifically involved in carrying out epidemiological studies following chemical incidents, their staff were capable of coordinating and conducting such studies. In seven cases, this opinion was founded on their experience of undertaking or participating in studies organised in relation to chronic exposure situations.

The commissioning of studies was perceived as falling within the remit of three of the government departments interviewed, as well as the Medical Research Council Institute for Environment and Health (government funded body). A supportive role was identified for the Office of Population, Censuses and Surveys.

Training

Thirty organisations reported receiving requests to organise and/or participate in the delivery of training courses relating to the management of chemical incidents. Twenty-eight actively offered or participated in the delivery of such courses. The exceptions were the Department of Environment, which had no resources specifically available for training, and the NHS Executive, which perceived its role as informing the training and educational establishments, and professional bodies, of the needs and requirements of public health trainees.

The full range of courses was on offer, including both undergraduate and postgraduate degree programmes. The principal subject areas were risk assessment and risk management, epidemiology, toxicology, environmental monitoring and modelling, and emergency planning. Of particular interest were the speciality modules offered at MSc/MPH level in "incident management" by the Department of Environmental Health and Institute of Occupational Health, University of Birmingham; the Department of Epidemiology and Public Health, University of Newcastle; the Environmental Epidemiology Unit, London School of Hygiene and Tropical Medicine; the Scottish Centre for Infection and Environmental Health; the South East Institute of Public Health; and the Welsh Combined Centres for Public Health.

International Activities

A total of 30 organisations were engaged in international activities. Twenty-two had contributed to the development by international organisations of public health related plans for response to chemical incidents and 21 to the development of international training materials and methods. The main international organisations involved were the International Programme on Chemical Safety (IPCS), the Organisation for Economic Co-operation and Development (OECD) and the World Health Organisation, in particular its European Office (WHO EURO).

Section D - Gap Analysis

General

A consistent view presented by 14 of the 41 organisations interviewed was "the apparent lack of any organised response in the United Kingdom, in relation to the public health management of chemical incidents". Specific comments included "the Department of Health and NHS need to better define not only their own roles, but also promote public health interests within the roles of other response agencies" and "at present, there is a lack of coordination and communication between the multiplicity of agencies involved, with many having unrealistically compartmentalised views of their respective responsibilities in relation to incidents". Others expressed their lack of understanding about the lead role of the HA in managing the public health aspects of chemical incidents and in carrying out longer term surveillance of those exposed.

The support provided currently to the Department of Health and NHS in meeting their responsibilities for managing the public health aspects of chemical incidents was independently viewed by 6 organisations as being dependent on the ad hoc involvement of a number of interested individuals, as opposed to a coordinated evidence-based system of response. However, this is not entirely true, given the existence of both the NPIS network and the HAGCCI advisory system in the UK.

Specific

Surveillance

Nine organisations considered that there was an urgent need for surveillance of chemical incidents to be co-ordinated on a national basis, and that a starting point might be to harmonise the data collected by the surveillance networks already in existence in the United Kingdom.

Environmental Monitoring and Modelling

Whilst acknowledging the fact that a number of agencies have statutory responsibilities in respect of environmental monitoring following chemical incidents, six organisations felt that practical advice and guidance urgently needed to be developed on the nature and extent of environmental monitoring programmes to be instituted in such circumstances. One of the organisations went further in commenting that "monitoring was mainly undertaken to prove that safety levels had not been exceeded and not to measure health risk". Another stated that "there were already well-defined methods, rationales and databases of results in occupational settings, but that this was not the case in relation to community exposures".

Five organisations also commented on the problems of obtaining good exposure information at the time of an incident. Three of the 5 considered that improved methods for modelling pollutant dispersion in all three environmental media of air, water and soil were required, in order to be able to better predict the dose of chemical(s) to which the community may have been exposed. The use of GIS was also seen as an integral part of this development by two of the organisations.

Emergency Preparedness / Planning

Four organisations observed that whilst appropriate provision had been made for on-site and off-site emergency planning at CIMAH sites, no such steps had been taken in relation to small and medium sized enterprises. Most incidents occurred at non-CIMAH sites and yet, there was no requirement for the operators to prepare emergency plans for dealing with incidents involving chemicals stored, processed or disposed of at their premises. Comments were also made by two organisations that "ambulance service personnel and police officers attending the scene of a chemical incident were often poorly equipped in terms of personal protective equipment". Guidance was needed in relation to this issue.

Risk Assessment

Two organisations were of the opinion that more extensive and scientifically based assessments of risk were required in order to guide risk management and risk communication decisions. There was also an urgent need for "Environmental Exposure Levels" to better determine the risk mitigation measures to be implemented at the scene of an incident. This was particularly the case with respect to contamination of the atmosphere. Additionally, it was considered that the assessment process should embrace both the acute and longer term health effects of people exposed to an incident.

Risk Communication

One organisation commented on the importance of managing the perception of risk by the public, following a chemical incident. In particular, there was a need "to develop risk communication techniques to help the public better appreciate magnitudes of absolute relative risk, and population attributable risks".

Epidemiological Follow-up

The lack of epidemiological follow-up of chemical incidents was highlighted by seven organisations. All considered that such studies were important, not only where there were acute cases of ill health, but also where people were exposed and not acutely harmed. Four of the 7 organisations also commented that most of the information on the toxicology of chemicals was currently based on animal studies and occupational studies, and that epidemiological follow-up of incidents was required to better establish the dose-response relationships between particular chemicals and human health effects, including those on the human foetus.

Additionally, the same four organisations called for the co-ordinating focus of an identified centre or network of units to oversee the arrangements for the epidemiological follow-up of chemical incidents. Two of the organisations also recommended the development of guidance materials on epidemiological approaches for the assessment of the human health effects of chemical incidents. Both felt that criteria were urgently needed to support public health professionals in making decisions on when to conduct a follow-up study. In particular, the cost-benefit equation was an important factor in determining whether the costly commitment of undertaking an epidemiological study was likely to be of benefit to society, where the evidence of a health risk was small.

Training

Nine organisations believed that public health doctors required more training, particularly in toxicology, environmental medicine, and environment and health issues. Three of the 9 organisations felt very strongly that these aspects should all be constituent parts of the formal training of any medical practitioner, and that continuing professional development should be no more than a means of supplementing and building on that training.

No observations were made in relation to "registration of sites / carriers", "biological sampling", "analytical services", "risk management" and "international activities".

Possible Models

Based on the general and specific comments gained from the gap analysis, a number of models for mobilising expertise to support the Department of Health and NHS in the public health management of chemical incidents were recommended:

(a) **Model 1 - the centralised "task force" model (Figure 6.2).** This was viewed as an independent and centrally funded unit, with the power to react with appropriate expertise and resource on a 24 hour, 365 day basis. Staff of the "task force" would be on permanent standby, enabling the provision of a rapid-response field service to manage the investigation and control of any chemical incident, on behalf of the HA or Regional Office. When not in the field, staff would be engaged in preparedness planning for future responses, national surveillance of incidents, development of training and education programmes, and various research and consultancy activities. None of the four organisations who favoured the model felt that the "task force" should be attached to any existing institution.

(b) **Model 2 - the centralised support model (Figure 6.3).** Very similar to model 1 and based on the existing system of communicable disease control in the United Kingdom. Indeed, views were expressed that the brief of the PHLS' Communicable Disease Surveillance Centre might simply be extended to include chemical incidents. The key differences between this model and the "task force" model were that (a) it was intended to support the role of the HA and / or Regional Office in the management of a chemical incident, rather than assume responsibility, and (b) it might be possible to incorporate a regional tier, as had occurred with the appointment of "regional epidemiologists" for the communicable disease model, to assist, when requested, with local investigations. Staff at the central unit would fulfill the same roles of preparedness planning, surveillance of incidents etc., as those for model 1. This model was supported by 6 of the organisations interviewed.

(c) **Model 3 - the regional "support" model (Figure 6.4)**. Seven organisations favoured a regional support network, with units developed on the basis of the eight NHS regions in England. Each unit would provide services similar to those of the centralised "support" model, which would include preparedness planning, surveillance of incidents etc. To ensure a consistency of approach between the eight units, there would also need to be a national co-ordinating centre for the development of appropriate guidelines and standards for joint working.

There were, however, some differences of opinion regarding the extent of the remit of the regional units. Three of the 7 organisations considered the role of such units to provide support and advice only, whilst four felt that a more hands-on approach could be offered, for example in providing on-site environmental monitoring support, participating in press briefings and assisting the HA in the epidemiological follow-up of those exposed.

(d) **Model 4 - NPIS "support" model (Figure 6.5)**. Identical to model 3, but with only five support units, located on the geographical basis of the existing NPIS network in England and Wales.

Whatever the preferred model, seven organisations commented on the need for adequate funding to be provided. Four of the 7 also stated that the staffing of units, whether at the central or regional level, needed to be carefully considered. The mix of skills required to effectively support the public health response to chemical incidents was more than just knowledge of the toxicology of chemicals. It also needed to embrace disciplines such environmental monitoring and modelling, health risk assessment, risk communication, and epidemiology.

Figure 6.2 Centralised "Task Force" Model

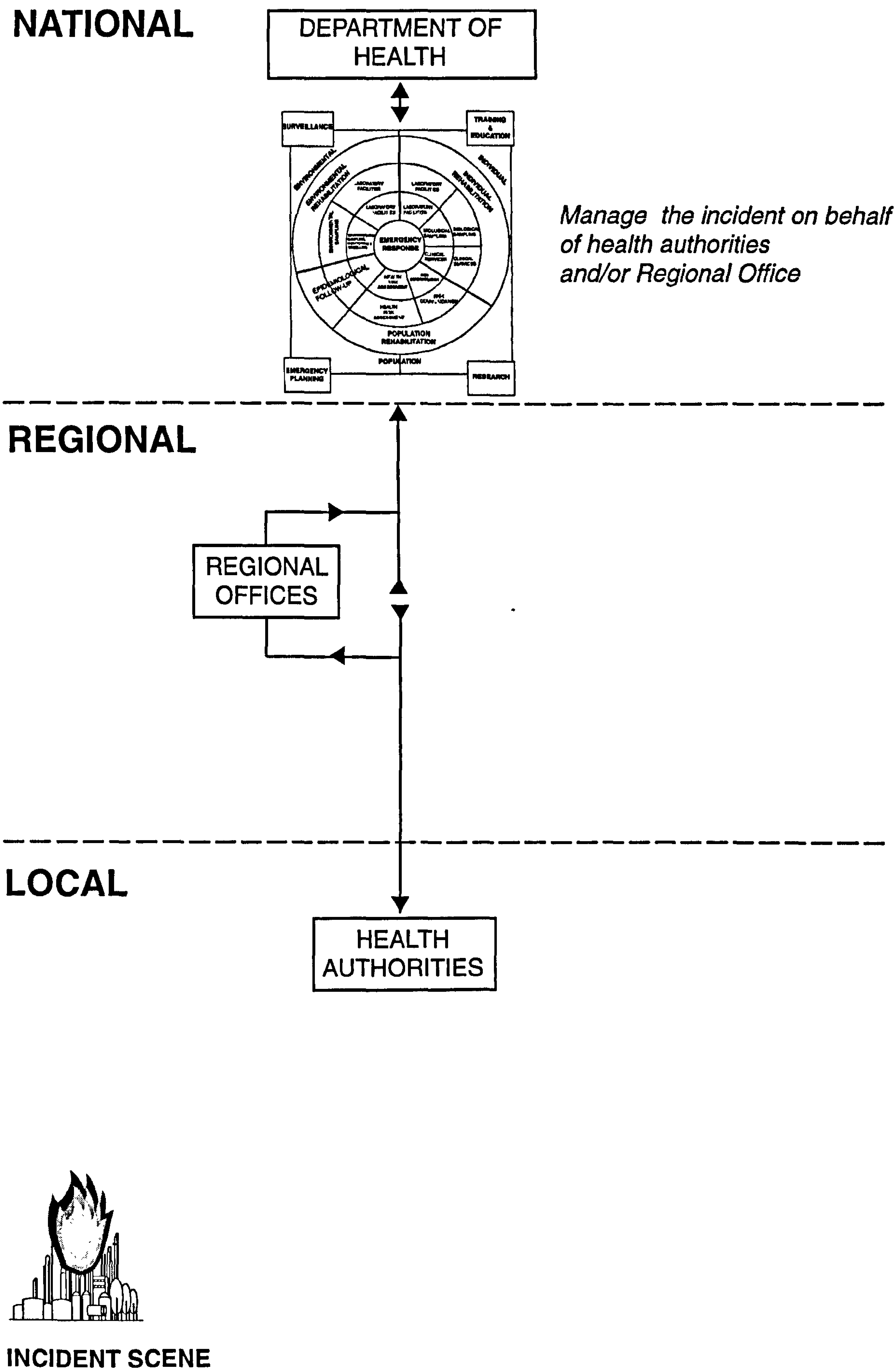


Figure 6.3 Centralised Support Model

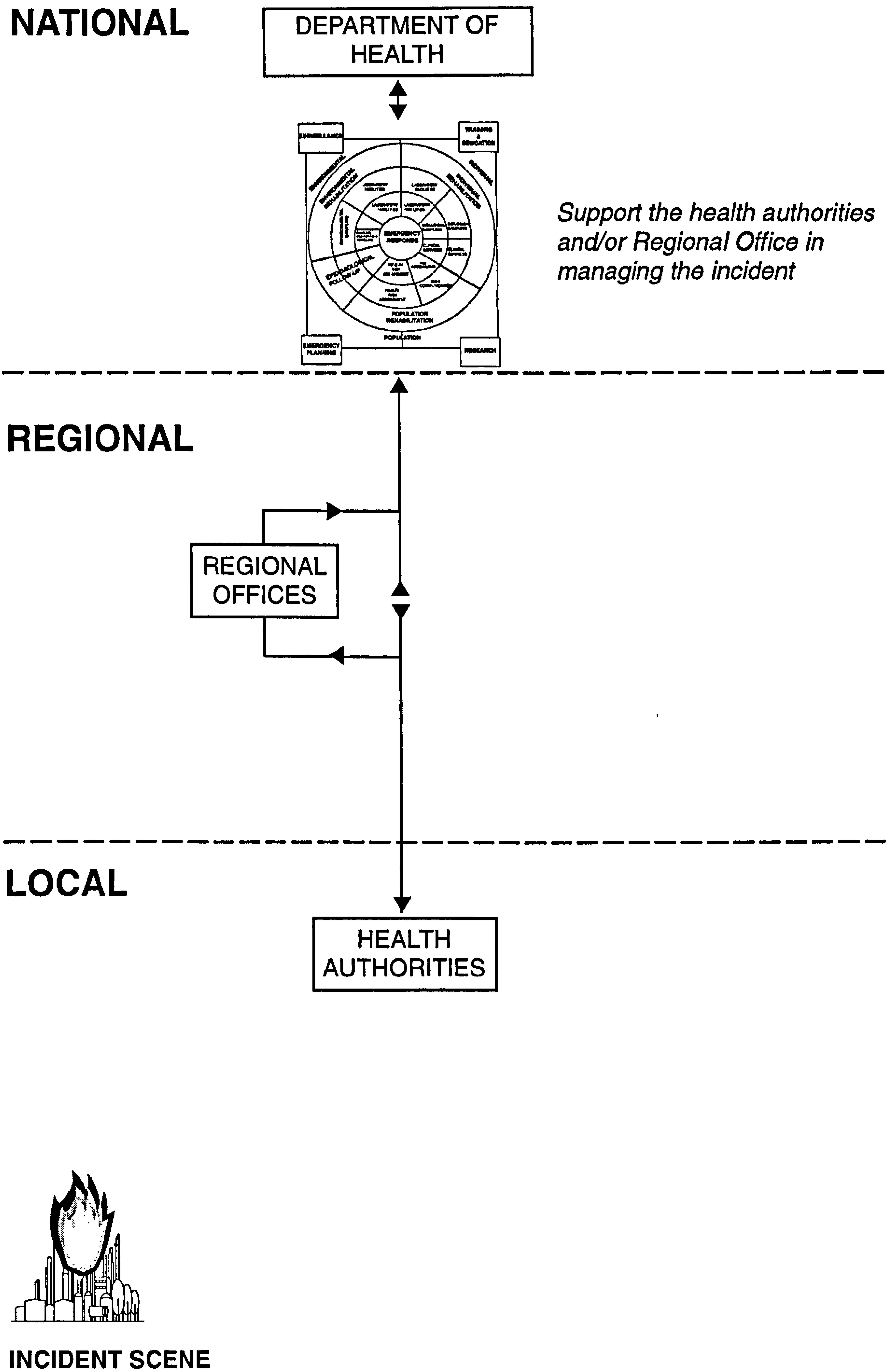


Figure 6.4 Regional "Support" Model

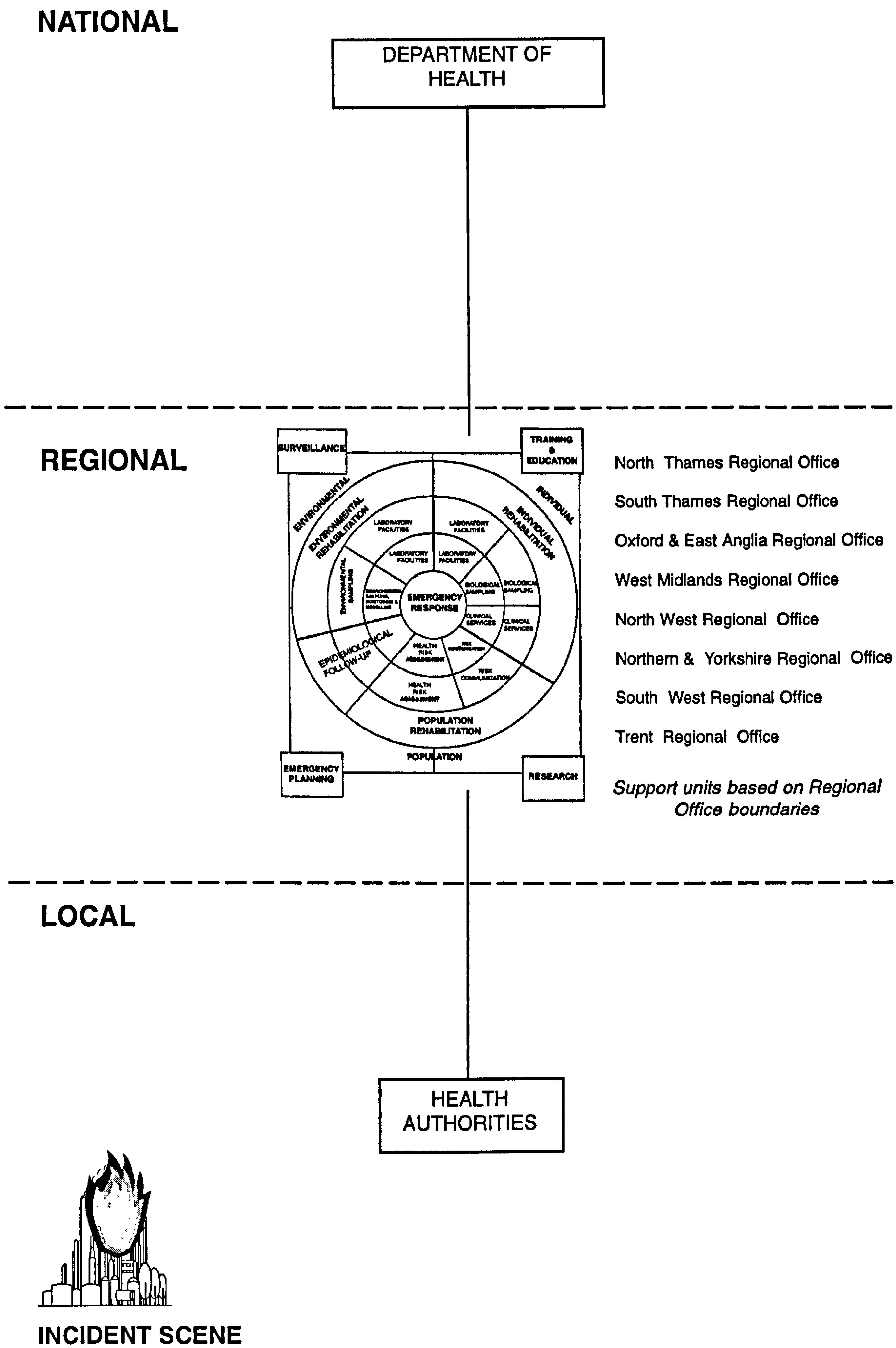
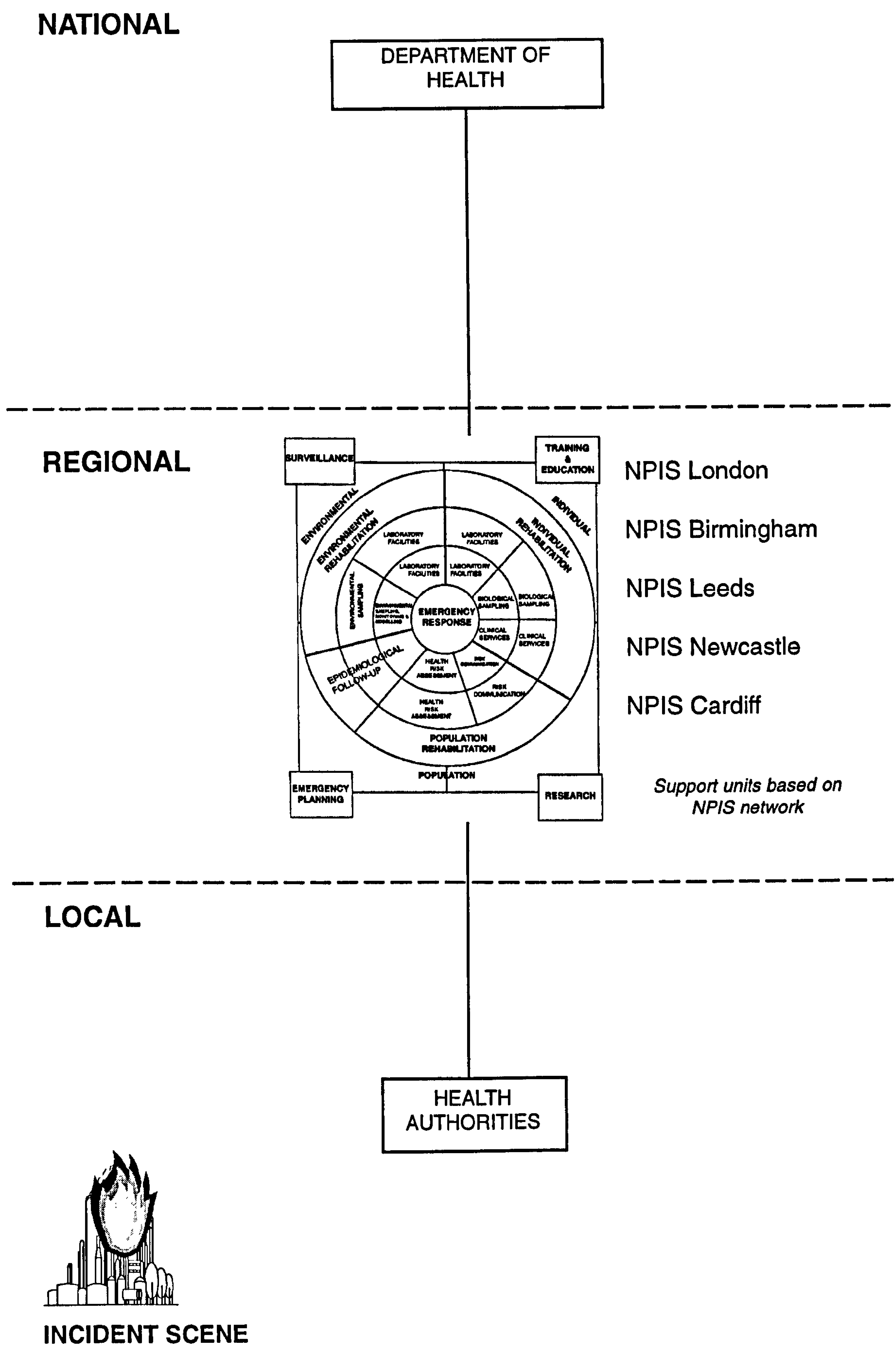


Figure 6.5 NPIS "Support" Model



Six organisations stated that any proposals, in respect of the establishment of regional and / or central units, would require the widest possible consultation to ensure ownership by future users. As part of the consultation process, there would need to be liaison with all agencies / authorities having a role to play in response to chemical incidents. This would include not only the NHS, but also industry, "Other Government Departments" and local response agencies. Eight organisations specifically asked that the interests of local authorities, particularly Environmental Health Departments, and the emergency services be taken into account.

Other comments included "the Centre or Units should not be a re-creation of Health Advisory Group for Chemical Contamination Incidents (HAGCCI)". The latter was seen as having too narrow a remit, with question marks over the availability of key individuals when most needed.

Discussion and Conclusions

The study design provided a useful framework on which to base an evaluation of the expertise and resources currently available within the United Kingdom for supporting the Department of Health and the NHS in meeting their roles and responsibilities with respect to the management of the public health aspects of chemical incidents. However, from the author's perspective, the study did have its limitations:

(a) originally, it had been anticipated that structured interviews would take place with approximately 25 organisations. Through consultation with the Department of Health, the number rapidly increased to 41, to account for as many UK organisations as possible, active in the areas of interest. This placed extreme time constraints on the author in completing the study on time, with inevitable impacts on quality.

(b) in that interviews were conducted by the author and two other interviewers, the study was immediately open to potential bias. Details of the measures implemented to overcome this potential problem have already been provided in this Chapter.

(c) the study findings were based on overviews of the stated activities of the organisations interviewed. Most interviews lasted less than 2 hours and therefore a detailed insight into the activities of the organisations, many of which were complex, intersectoral and multidisciplinary in nature, was not possible. In particular, it was felt that additional time was needed to thoroughly assess the claims made by some organisations of their actual capabilities to react to various aspects of the response to chemical incidents.

(d) there can be no guarantee that the opinions of the interviewees were the same as those of the organisations which they were representing. In relation to the gap analysis part of the study, for example, many interviewees expounded their own personal views, as well as those of their organisations.

Notwithstanding these limitations, the underlying conclusion, in relation to all of the activities considered, from surveillance to epidemiological follow-up and from environmental monitoring to risk communication, was the need to change from the current position where support was provided to the Department of Health and NHS by the ad hoc involvement of a multiplicity of individuals and organisations, to a systems-based co-ordinated approach at the regional and national level.

Clearly, there were many organisations already active in the areas where gaps in support were identified. Foci of coordinated activity were present in Wales and the NHS (South and West) Region, the NHS (West Midlands) Region, the NHS (Northern and Yorkshire) Region and Scotland. There were, however, no similar foci of activity in any of the other NHS Regions. Furthermore, there was no inter-regional coordination of the activities being undertaken. This was perceived as particularly important where incidents had the potential to impact on more than one NHS Region.

A number of possible models were therefore recommended to the Department of Health, and the suggestion made that their evaluation should form the basis of a separate research study. In particular, the issues requiring further detailed consideration included:

(a) the location(s) and remit of any central / regional units;

(b) the funding mechanisms;

(c) the breakdown of expertise that would need to be retained within any central / regional units; and

(d) the way any central / regional units would be expected to work both together and with other agencies / authorities, for example, the emergency services.

A two-stage process to the study was proposed:

Part A: the production of a discussion paper, based on the models already highlighted;

Part B: widespread consultation on the paper, involving not only the Department of Health and the NHS, but also those organisations interviewed in the present study, and other local response agencies.

The author's report was submitted to the Department of Health on 10 May 1996.

The Role of the Public Health Medicine Environmental Group

Having now considered the respective roles of the professional monopolisers and the corporate rationalisers in the development of the model, it is timely at this point to introduce the third grouping, that is, what Alford referred to as the community interest (Alford 1975). In relation to the model, no other organisation did more to influence policy than the Public Health Medicine Environmental Group (PHMEG), part of the Faculty of Public Health Medicine.

In 1995, the PHMEG conducted a survey of its members to identify which health professional within each HA had been designated as the "appropriate officer" for the purposes of effecting compliance with HSG (93)38 and HSG (93)56 in England, and WHC (93)61 and WHC (94)26 in Wales (see Chapter 4). The survey found that responsibility rested with CsCDC in 88% of HAs (Public Health Medicine Environmental Group 1996).

On further questioning of CsCDC, the survey also confirmed their need for:

> ... access 24 hours a day to advice on the public health, medical, environmental, chemical, scientific and toxicological aspects of chemical health hazards.
>
> (Public Health Medicine Environmental Group 1996)

Although acknowledging the ability of the NPIS to provide specialist toxicological advice (Murray 1992), the PHMEG concurred with Hill and O'Sullivan's view that the service could not meet the additional needs of CsCDC in dealing with the reality of a chemical incident (Hill and O'Sullivan). The PHMEG concluded that:

> ... a contract must therefore exist between Districts (HAs) as purchasers and a toxicology unit or other suitable unit as providers to ensure that Districts are able to comply adequately with the guidelines.
>
> (Public Health Medicine Environmental Group 1996)

In this respect, the PHMEG convened a working party to develop a draft specification for a contract with such a provider unit. The draft specification was issued on 24 January 1996 and is reproduced at Appendix 6.6.

The PHMEG were, by now, also conscious of ongoing developments with respect to each of the four support and advisory units in England and Wales. Accordingly, the group decided to hold a meeting of its members, referred to in correspondence as a "marketplace meeting" (see Appendix 6.7), to which representatives of each of the units were invited to make a 30 minute presentation, detailing the level of service that they were able to provide against the PHMEG's specification and the costs involved. The author was therefore invited, in his capacity as Head of CIMSU. The meeting was scheduled for 27 March 1996, but was later postponed, pending the outcome of the Department of Health's "Study of Activity on Public Health Effects of Environmental Chemicals".

Ten days after the report of the study was submitted (10 May 1996), the Department of Health received a letter from the PHMEG outlining seven areas of concern, expressed by its members, in relation to the impact of subscription services for public health support in the management of non-communicable environmental hazards (Monk 1996). These are summarised in the first column of Table 6.2.

To address these concerns, the Department of Health convened a meeting on 31 May 1996 to which the "Heads" of all four support and advisory units in England and Wales were invited. Also in attendance was the secretary of the PHMEG, and representatives of the Department. At the meeting, the author made the comments detailed in the second column of Table 6.2, in relation to the areas of concern raised by members of the PHMEG. The author also stated that the Department of Health would need to consider (a) how it could best obtain the advice it required to alert and brief the Chief Medical Officer, Ministers and / or its own media liaison officers, and (b) how each of the four support and advisory units would interface with the HAGCCI advisory system.

Table 6.2 - Areas of Concern expressed by the PHMEG regarding the Introduction of Subscription Services and the Author's Response

PHMEG Concerns (Monk 1996)		Author's Response at DH meeting	
1.	What happens to those HAs without a subscription when they have a major incident?	1.	Can really only be addressed through a centrally funded support service. If 4 out of the 5 HAs in Wales subscribe to CIMSU and a major incident occurs in the nonsubscribing authority, it would be very difficult to say "no, we cannot help you" to the DPH / CCDC. However, is this fair to the other HAs who are paying? There are therefore ethical and moral questions as to whether such public health issues should be subject to the marketplace.
2.	How are examples of good practice to be shared by the support units? How will the units be coordinated?	2.	Surveillance must be nationally co-ordinated. Perhaps one of the support units could act as a clearing house to receive incident reports from the others. This would not preclude each unit from disseminating its own newsletter etc. Through the mechanism of a clearing house, surveillance would also be better able to provide guidance on training requirements and R&D priorities nationally. It would also seem sensible for any system to be tied in with the WHO Collaborating Centre, Cardiff.
3.	Training must be nationally based. How will it be coordinated?	3.	Training provision has been reviewed as part of the DoH study. Training must be considered in a broad context from undergraduate and postgraduate courses to short courses / workshops / simulation exercises / conferences. There are a multiplicity of current players providing training and what is required is for the PHMEG to initially define the specific needs of their members. These can then be evaluated against current provision in the United Kingdom and shortfalls addressed on a national basis.
4.	If a non-communicable environmental hazard occurs in a district which is contracted with provider A, but comes to the attention of provider B, who does provider B inform, the CCDC in the district where the episode has occurred or provider A ?	4.	Whether the provision of a service is left to the marketplace or centrally resourced, such agreements will have to be reached. All of the support units will have to embrace the need for clear lines of communication and responsibility. If left to the marketplace, however, it is doubtful whether this can be achieved - competitors, for what effectively is business, are unlikely to co-operate and share information and ideas.
5.	In cross-boundary incidents, where the two districts involved contract with provider A and provider B respectively, how will consistency of advice be assured?	5.	As for point 4, but there may be an additional complication. It has always been the intention to offer the services of CIMSU to both local authorities and HAs. A potential problem might arise where CIMSU is contracted to provide advice to a local authority, but the HA for the same area subscribes to another support unit. This could lead to conflicts in the advice given by the two units to their respective clients.
6.	How will long term surveillance be coordinated?	6.	These are issues which fall within the remit of CIMSU. Indeed, in Wales it is the medium to long-term health concerns that are more regularly being faced by CCDCs and EHOs. CIMSU will provide support and advice only. Should a fuller study be warranted, then this would be undertaken on a consultancy basis and/or through collaboration with other agencies, for example, SASHU in the investigation of such incidents.
7.	How will research priorities in the area of non-communicable environmental hazards be decided?	7.	Both nationally and locally; what is important is that any activity is co-ordinated, for example, one of the support units may be proposing to investigate the public health impact of formaldehyde emissions from a wood chip manufacturer. Through collaboration, it may become evident that such a study has already been undertaken by another Unit and that important lessons can be learned. Alternatively, the study power could be increased by a collaborative investigation in relation to a number of such plants across the United Kingdom.

Conclusion

The PHMEG played an important part in representing the interests of its members, who in turn, were to be the main clients of any public health management model developed for dealing with acute chemical incidents. Armed with (a) the views of the PHMEG, (b) knowledge of the current status of the four support and advisory units (the professional monopolisers), and (c) the conclusions and recommendations of the author's report on the "Study of Activity on Public Health Effects of Environmental Chemicals", it was now left to the corporate rationalisers, that is the Department of Health, in consultation with Welsh Office, the Scottish Office Department of Health and the Department of Health and Social Services, Northern Ireland to determine the way forward.

Chapter 7 - Model Selection

Introduction

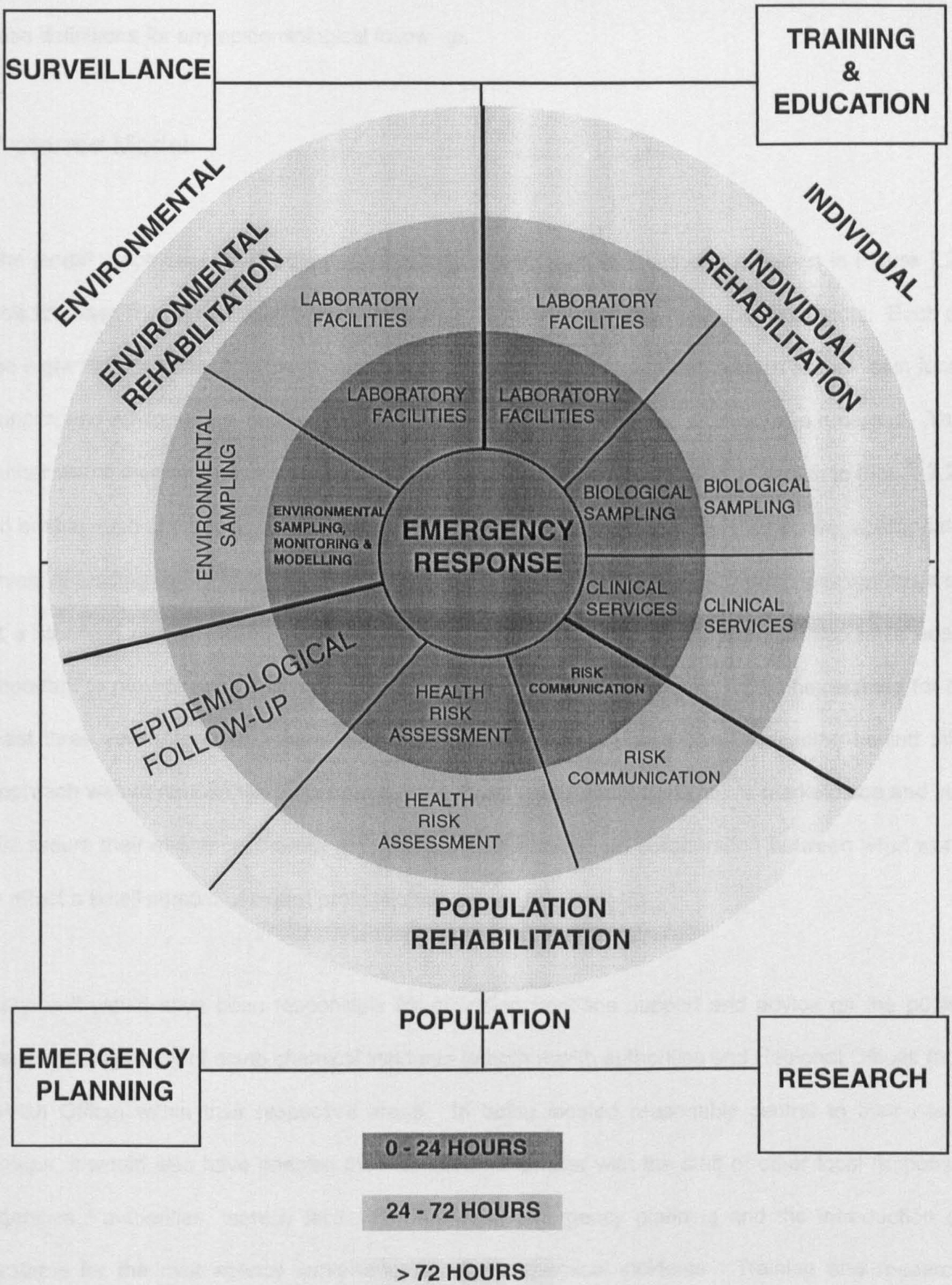
As will have been evident from the previous Chapter, the author has had a developmental role in all stages in the formulation of a public health management model for dealing with acute chemical incidents, not only for Wales, but for the whole of the United Kingdom (UK). In this Chapter, the author will detail the system requirements for any support and advisory system so developed, and will also put forward the model that he would personally have selected for England and Wales. However, the ultimate decision rested with the Department of Health, in consultation with Welsh Office, the Scottish Office Department of Health and the Department of Health and Social Services, Northern Ireland. The final model selected will therefore be described, as will its evolution into a fully operational system.

System Requirements

Figure 7.1 provides the author's proposed schematic model of the skills, facilities, expertise and resources which any support and advisory system would need to provide to central government health departments and those other parts of the National Health Service (NHS), primarily health authorities, responsible for dealing with the public health aspects of an acute chemical incident. The model has been developed on the basis of (a) a systematic review of the available literature, (b) the lessons learned from the AWEHSP, (c) the specific gaps in current provision identified by the "Study of Activity on the Public Health Effects of Environmental Chemicals" and (d) consultation with the various health interest groupings over a year.

The model comprises five components. A reactive component, that is, emergency response, lies at the heart of the model, as it is in relation to this aspect that the effectiveness or otherwise of any government health department and/or health authority will ultimately be measured by the public. The four proactive components of surveillance, training and education, emergency planning and research are included to ensure that there will always be a continual drive towards the improvement of the emergency response. From the research undertaken, it is also evident that different skills,

Figure 7.1 Model delineating the expertise and resources by any service established to support and advise on the public health management of an acute chemical incident



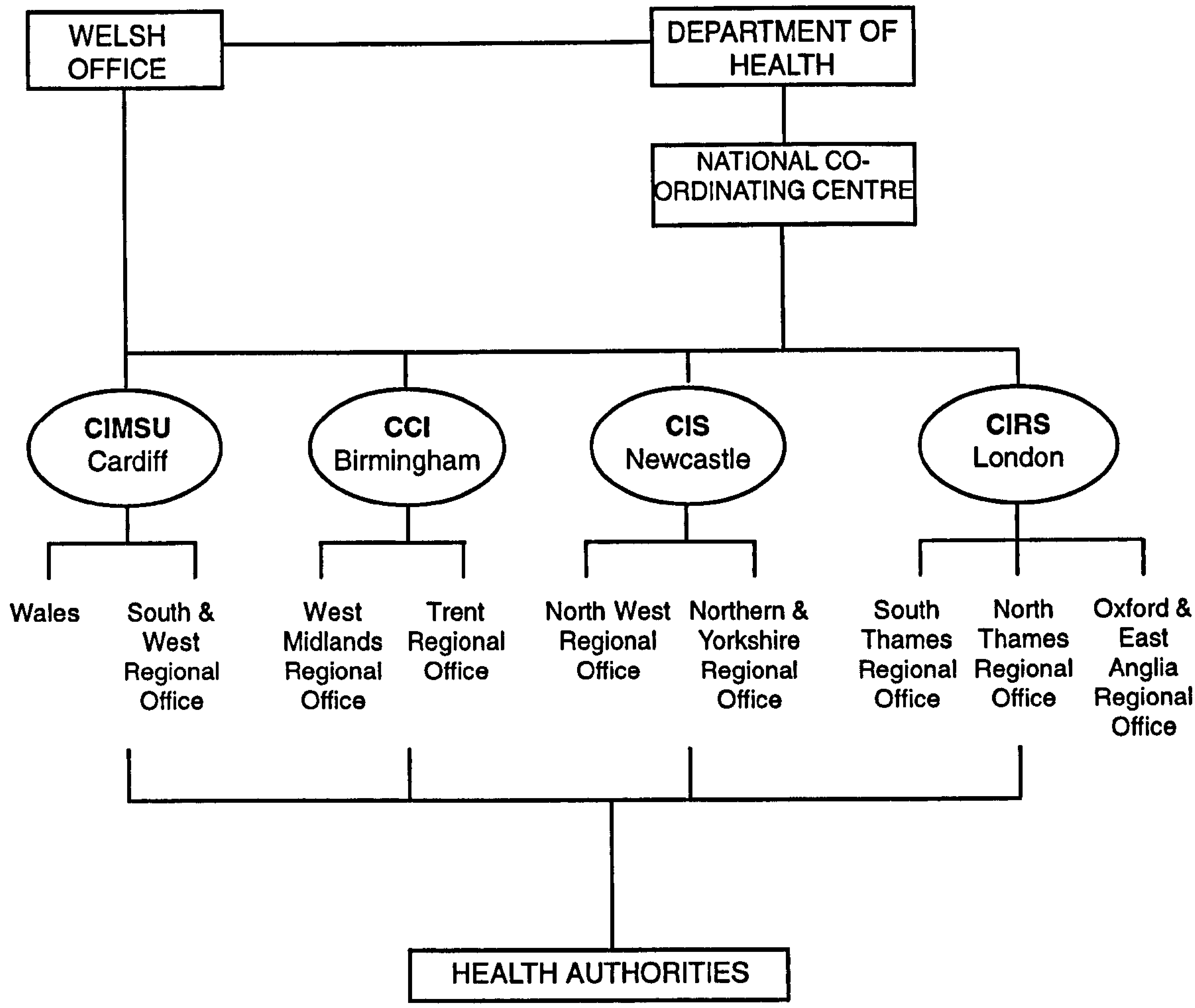
facilities, expertise and resources are required to support the public health management of an acute chemical incident over time, as represented by the three concentric circles in the model. Finally, the skills, facilities etc. are further separated into actions directed at the individual, the population and the environment, although, in practice, there will be considerable cross-linkage, for example, between the results of environmental monitoring and decisions on population health risk assessment; and between the recording of clinical symptoms in individuals and the establishment of case definitions for any epidemiological follow-up.

Preferred Model

The model which best fits the theoretical rationale developed in this thesis is shown in Figure 7.2. This idealised model has been based on political considerations and resource constraints. Each of the eight NHS regions in England, together with Wales, should have had access to their own local support and advisory unit, such as CIMSU. Unfortunately, only four such units have emerged. The author would therefore have separated England and Wales into four areas, as shown in Figure 7.2. To enable each of the units to meet effectively the system requirements detailed above, appropriate levels of funding would have been levied from health authorities, either on a per capitation basis or at a standard rate applicable across the whole of England and Wales. It would also have been important to provide each unit with assurances that such levels of funding would be retained for at least three years, to enable them to attract appropriate expert staff. The reasoning behind this approach was to remove the units from the cut-throat world of the competitive marketplace and yet still assure their existence, thereby encouraging cooperation and collaboration between what were in effect a small number of expert professionals in the UK.

Each unit would have been responsible for providing front-line support and advice on the public health management of acute chemical incidents to both health authorities and Regional Offices (not Welsh Office) within their respective areas. In being located reasonably central to their client groups, it would also have enabled them to become familiar with the staff of other local response agencies / authorities, thereby facilitating improved emergency planning and the introduction of systems for the multi-agency surveillance of acute chemical incidents. Training and research activities could also have been tailored to meet local needs.

Figure 7.2 Preferred Model



KEY:

CIMSU	Chemical Incident Management Support Unit
CCI	Centre for Chemical Incidents
CIS	Chemical Incident Service
CIRS	Chemical Incident Response Service

However, the development of such a system did not preclude the need for a national co-ordinating centre. This was required to ensure that all health authorities and Regional Offices received equivalent standards of service irrespective of the unit that was providing support to them. Procedures also needed to be established for the handling of cross-border incidents and for the coordination of incidents of national significance. Other roles for such a centre might include national surveillance of incidents, and an alerting / briefing role for the Department of Health and Welsh Office.

The Model Selected

All four government health departments demonstrated their commitment to finding an appropriate model for the future, in jointly endorsing the following action point in the "United Kingdom National Environmental Health Action Plan", published in July 1996:

> ... The Government will explore the most effective way of providing support to public health authorities in their response to chemical accidents and in the wider monitoring and surveillance of public health to detect possible adverse health effects of chemicals in the environment.
>
> (Department of the Environment 1996)

The decision, however, came via a Department of Health communiqué to the author and the "Heads" of the other support and advisory units, dated 4 July 1996. Following Departmental discussions with the RDsPH, it had been agreed "that it would be sensible for each of them to coordinate, within their own region, arrangements for the response to chemical incidents locally". Whilst it was left to the discretion of the RDsPH, every encouragement was given to ensuring "that the provision of any support service from outside the Region (took) into account the fact that incidents cross boundaries, and this would quite likely mean that a single service provider would be sensible". In short, the Department was retaining the market model of health service provision for the fixing of contracts between health authorities and the various support and advisory units, whilst at the same time adopting a bureaucratic style to encourage each Region to ensure that its constituent health authorities all contracted with the same unit.

The Department of Health also recognised the need for a coordinating centre, and indicated its intention to "develop a framework in order to invite tenders for a 24 hour, 365 day national focus for work on chemical hazards". The initial functions identified for such a focus were "(a) to provide a contact number available in the event of an incident, and to direct callers to appropriate sources of information and expertise; (b) to ensure regional surveillance arrangements are in place and compatible on a nationwide basis; (c) to provide information on relevant training and, perhaps, to promote suitable training opportunities; and (d) to maintain a proactive role in identifying needs, and to provide a resource to assist with maintaining a consistent approach across the country." The bureaucratic model of health service provision was therefore set to remain at the national level.

The inference from the communiqué was that the framework would be developed as a matter of priority, but that this did not preclude any regional arrangements for contracting from moving ahead of that time-scale. The decision immediately resulted in a flurry of activity in the "marketplace", with all four units vying against each other for health authority contracts. However, in reality, the two elements of the public health management model progressed in parallel.

CIMSU

The suggested regional approach to contracting was followed. For 6 of the 8 regions in England, there was little competition between the units, with contracting undertaken on the basis of geographical location, and personal and professional contacts. The Centre for Chemical Incidents, Birmingham was contracted to provide support and advice to health authorities in the NHS (West Midlands) Region through top-sliced funding at Regional level; the Chemical Incident Service, Newcastle to health authorities in the NHS (Northern and Yorkshire) Region; and the Chemical Incident Response Service, London to health authorities in the NHS Regions of North Thames, South Thames, Oxford and East Anglia, and the North West. These decisions were taken over differing time-scales, to which the author was not party.

With respect to CIMSU, the first task for the author was to re-write the service delivery plan, in light of PHMEG's specification and having regard to the views of the project advisory group established for the SWEHSP. A copy of the revised plan is reproduced at Appendix 7.1. Although the author was invited by letter, dated 6 August 1996, to tender for health authority contracts within the NHS (Trent) Region, the decision was taken, in conjunction with the Directors of the three centres comprising CIMSU, to confine the service to local and health authorities in Wales and the NHS (South and West) Region. On this basis, the author embarked on a series of meetings to market the Unit to local and health authorities within these areas.

In Wales, the Welsh Office took a similar line to that of the NHS Regions in England, enacted by a letter from the Chief Medical Officer to the DsPH of the 5 health authorities, suggesting that it might be in their collective interests to contract with a single support and advisory unit, such as the one located within the principality. The NHS (South and West) Region did likewise, given the pump-priming that it had already provided to support the project advisory group, and the marketing of CIMSU. However, it soon became apparent that CIMSU was disadvantaged by the fact that it was still a developmental unit. Subsidised by funding and manpower from each of its constituent centres, the decision was therefore taken to formally launch CIMSU on 9 September 1996.

Accordingly, a dedicated 24 hour chemical incidents hotline was installed at the Welsh National Poisons Unit, and the number distributed to subscribing authorities (at this stage only 12 local authorities had contracted with CIMSU). On receipt of a call, the author was immediately paged. Contact was then made with the original caller within a target time of 15 minutes. Given the facts of the incident, the author either provided direct advice over the telephone, asked Poisons Unit staff to fax datasheets on the chemicals of interest to the caller and / or facilitated liaison between the caller and appropriate experts within each of the three constituent centres, for example, the staff of the Welsh Combined Centres for Public Health in environmental epidemiology.

In spite of the direction provided by the project advisory group, which met on a quarterly basis during 1996, the strong marketing policy of the Chemical Incident Response Service, London and the offer of a service at a price £500 less than that of CIMSU soon created problems in securing contracts with health authorities in the Region. Eventually, the RDPH had no option but to follow the lead of the NHS (Trent) Region and put the contract out to tender. Unfortunately, for CIMSU, the contract was won by the London Unit, as was that with health authorities in the Trent Region.

For reasons that will soon become obvious, the author left his position as "Head" of CIMSU on 31 January 1997. At this time, 19 local authorities were contracted to the Unit (7 from Wales, 9 from the area of the NHS (South and West) Region and 3 from other parts of England). Gwent health authority, one of the 5 health authorities in Wales had also subscribed, with the remainder due to join on 1 April 1997. Expressions of interest were also starting to be shown in the Unit by the 4 Health Boards in Northern Ireland.

The National Focus

On 16 August 1996, the Department of Health placed an advertisement in a number of journals, inviting "tenders for the operation of a unit to act as a central Focus for work on response to chemical incidents and surveillance of possible health effects due to chemicals in the environment" (see Appendix 7.2). In accordance with the advertisement, the author registered an interest with the Department, on behalf of the WCCPH, to tender for the contract.

Following a shortlisting process, necessitated by the large number of expressions of interest received by the Department of Health, the WCCPH, along with seven other organisations were invited to tender for the National Focus. To guide the content of the applications, the Department of Health included a paper on the proposed "Scope of Work" of the National Focus within the tender documents. This is reproduced at Appendix 7.3.

The approach adopted by the WCCPH was essentially the same as that for CIMSU, that is, to pool the expertise and resources of three existing centres: (a) the Welsh Combined Centres for Public Health of the University of Wales College of Medicine in applied public health medicine and environmental epidemiology; (b) the Toxicology and Therapeutics Centre of the University of Wales College of Medicine in medical, occupational and environmental toxicology; and, (c) the School of Environmental Sciences at the then Cardiff Institute of Higher Education in environmental health and environmental risk management.

The author was responsible for preparing the WCCPHs application, which was submitted to the Department of Health on the due date of 11 November 1996. Eight days later, the author received a letter from the Department of Health, inviting the WCCPH to make a presentation on its bid to a tender panel. Two other organisations had also been shortlisted for interview. The presentation took place on 27 November 1996, and three weeks later, an offer was made in writing to the author for the WCCPH to enter into a contract with the Department of Health to provide a "National Focus for Work on Response to Chemical Incidents and Surveillance of Health Effects of Environmental Chemicals". The latter became operational on 1 February 1997, with the author appointed to the position of "Head of National Focus".

A Public Health Management Model for Acute Chemical Incidents in Wales

The Welsh Office immediately extended the remit of the National Focus to Wales, and by October 1997, the Scottish Office Department of Health and the Department of Health and Social Services, Northern Ireland had done likewise in respect of their own territories. The model that has been developed has therefore been applied throughout the UK, but for the purposes of the last part of this Chapter and the next Chapter, the model primarily considered will be that which relates to Wales only.

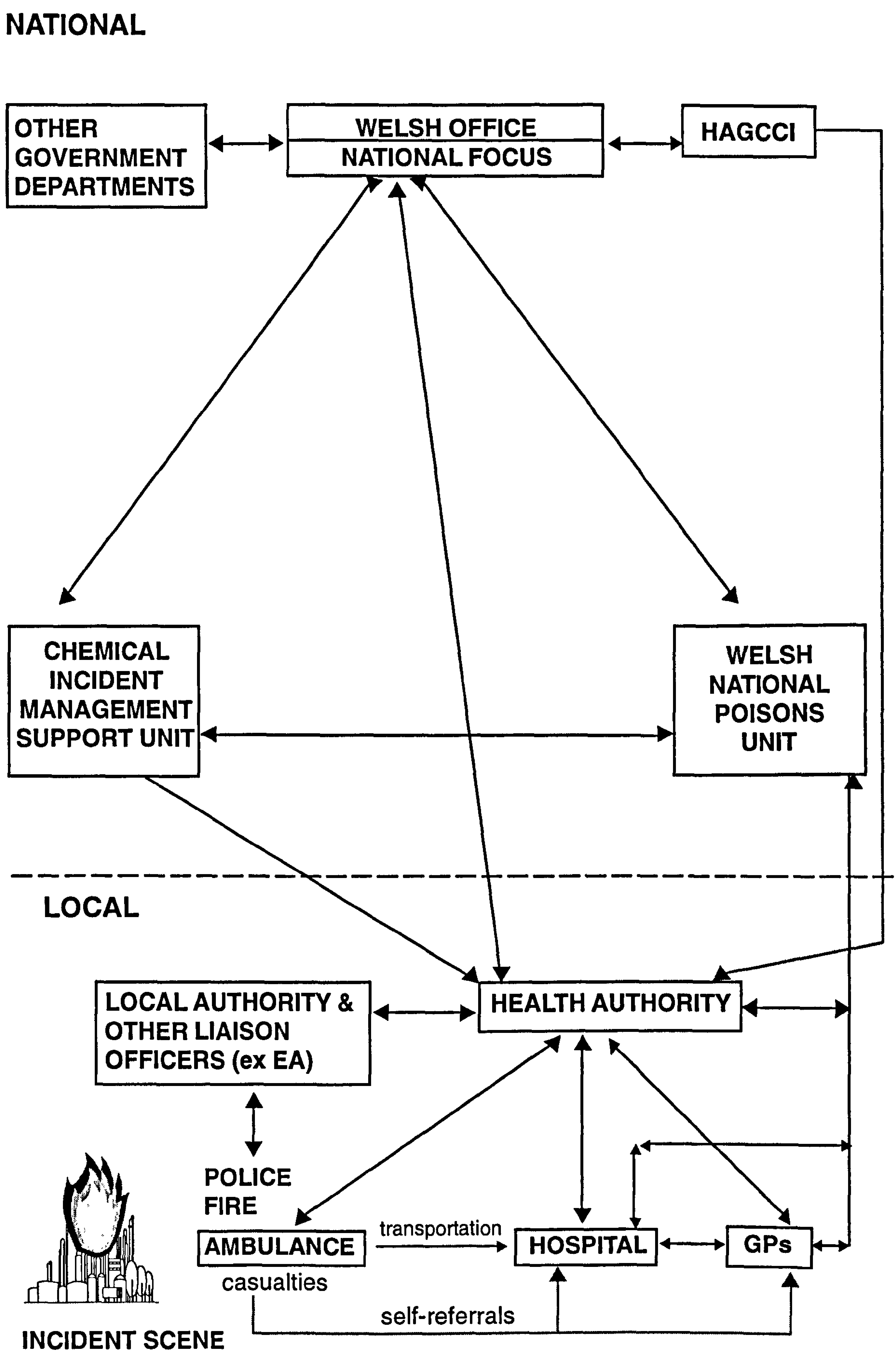
Figure 7.3 shows the model for Wales. As originally set out in WHC (93)61 (Welsh Office 1993), the primary health service responsibility for coordinating the health aspects of response to chemical incidents remains with the five health authorities. This includes:

(a) ensuring that satisfactory plans exist for the health authority response to an incident within the general framework of existing local emergency planning arrangements; and

(b) the designation of an individual responsible for ensuring that the health authority has access to the necessary support and advice concerning public health hazards arising from chemical incidents.

The latter individual in all 5 health authorities in Wales is the CCDC. In terms of the advice available to health professionals in Wales, in particular, consultants in accident and emergency medicine and general practitioners, the Welsh National Poisons Unit (part of the NPIS) still fulfills an important role in providing information on the hazardous nature of the chemicals involved in an incident and on the diagnosis, treatment and management of any casualties following exposure.

Figure 7.3 Public Health Management Model for dealing with Acute Chemical Incidents in Wales



However, as has been discussed in Chapter 6, this is only part of the advice needed by health authorities in being able to effectively respond to the public health aspects of a chemical incident. Accordingly, as of 1 April 1997, all have contracted with CIMSU for the provision of a 24 hours a day, 365 days a year support and advisory service on the public health, environmental, scientific, toxicological and epidemiological aspects of an acute chemical incident. CIMSU also furnishes a number of other services. These include:

(a) assistance with emergency planning;

(b) maintenance of systems for the surveillance of incidents; and

(c) preparation and delivery of appropriate training courses and materials.

The roles of the National Focus are:

(a) to extend and strengthen the ability of the NHS in Wales to respond effectively to chemical incidents, and the possible health effects of chemicals in the environment;

(b) to provide a telephone contact available 24-hours a day, 365 days a year;

(c) to provide assistance to the NHS in Wales, with respect to:

- epidemiological approaches to the assessment of both the short and longer-term health effects of chemical incidents; and
- methods of investigation for identifying the incidence and possible health effects of exposure to typical ambient levels of chemical contamination;

(d) to work closely with all relevant centres of expertise in the UK, for example, the Water Research Centre and the National Chemical Emergency Centre;

(e) to develop a national multi-agency surveillance system for acute chemical incidents in the UK, incorporating reports of incidents from CIMSU;

(f) to maintain a pro-active role in identifying the needs of the NHS in Wales in responding to acute chemical incidents;

(g) to promote joint planning between health interests and other key players locally, such as local authorities, the emergency services, and the Health and Safety Executive (HSE);

(h) to ensure that the providers of support and other related services (for example CIMSU) to health authorities on the border between Wales and England co-ordinate the coverage of their services and develop effective liaison;

(i) to provide information on relevant available training and to promote the development of further suitable training, if needed;

(j) to develop best practice protocols and guidance in areas of work covered by the National Focus, for example, criteria for the epidemiological follow-up of acute chemical incidents;

(k) to take over the responsibility from the Department of Health of activating the Health Advisory Group on Chemical Contamination Incidents (HAGCCI).

Under the new arrangements, when an incident occurs which requires greater expertise than is available locally, the CCDC will in the first instance contact CIMSU. Normally, this will enable the incident to be dealt with appropriately. If an incident is unusual, particularly complex, or is likely to have a major impact on public health, to attract national media attention or to span the Wales / England border, the health authority or CIMSU should contact the National Focus. The National Focus will then:

(a) alert officials at Welsh Office (and the Department of Health in the event of a cross-border incident), including media relations personnel;

(b) provide national coordination, if necessary;

(c) liaise with "Other Government Departments", such as HSE and Environment Agency;

(d) direct callers to appropriate sources of information and expertise in the UK or elsewhere; and,

(e) advise on circumstances in which HAGCCI can assist and, where the need arises, make arrangements for access to the relevant expert(s).

Chapter 8 - Model Implementation and Evaluation

Introduction

The model selected for Wales has been in place since 1 February 1997. It is therefore too early for any definitive conclusions to be drawn on the effectiveness or otherwise of the two complementary units that have been established. The aim of this Chapter is to review both the progress and the impact that has been made in Wales up to 31 March 1998 by the Chemical Incident Management Support Unit (CIMSU) and the "National Focus for Work on Response to Chemical Incidents and Surveillance of Health Effects of Environmental Chemicals" (hereinafter referred to as the National Focus), and to comment on the issues / concerns that have emerged over this fourteen month period.

Relationship between CIMSU and the National Focus

As already indicated in Chapter 6, CIMSU had been established and the tender for the National Focus prepared, on the basis of collaborative arrangements between the same three centres of expertise. However, CIMSU was a commercial unit and the National Focus, a government funded unit. The latter therefore had to be seen to be operating independently of CIMSU, with no cross-subsidisation of resources; and also equitably towards the other three commercial units in England, and the government funded Scottish Centre for Infection and Environmental Health (SCIEH).

Accordingly, steps were immediately taken to physically separate the two units by location, with CIMSU moving from its original base at the University of Wales Institute, Cardiff to the offices of the Welsh National Poisons Unit (WNPU) at Llandough Hospital, Cardiff, and the National Focus taking up new accommodation at the University. Appointments were also made to each unit, so that they were exclusively resourced by their own dedicated complements of "core" staff. However, this did not preclude the units from independently accessing the expertise and resources of each of the three centres underpinning their existence. For example, both units were able to make use of the same environmental epidemiologist(s) within the Welsh Combined Centres for Public Health, or the same chemical database resources held at the WNPU.

Obviously, as with any new developments, it does take time to make the necessary staff appointments and to re-locate office accommodation. Until 1 July 1996, there was therefore not such a clear demarcation, as that stated above, between the operational arrangements for the two Units, and the author was certainly aware of some allegations levied at the National Focus of cross-subsidising resources to CIMSU. This was not the case, but such allegations were an inevitable consequence of the market model within which CIMSU was expected to operate.

The management arrangements established for the two Units were also very different. For CIMSU and the National Focus, a "Project Executive Board" and a "Focus Management Executive" respectively were set up at the local level. However, to oversee the work of the National Focus and to take full account of its UK-wide remit, the Department of Health also brought into existence in April 1997 a national "Steering Group". The primary purpose of the Steering Group was to advise the National Focus on the development of its work programme, and to monitor the effectiveness and timeliness of its performance against objectives and target dates set (copies of the National Focus' Work Programmes for 1997/1998 and 1998/1999 are included at Appendices 8.1 and 8.2).

Outside of the Steering Group, which meets biannually, the National Focus has also established an informal and regular dialogue with CIMSU and the "Health Professionals Group" at Welsh Office during the past fourteen months, to discuss aspects of implementation of the work programme within the principality, and also to ascertain other tasks which Welsh Office may wish to take forward on a purely territorial basis.

Chemical Incident Hotlines

Both CIMSU and the National Focus have operated, on a 24 hours a day, 365 days a year basis, chemical incident telephone hotlines since 1 February 1997. Under an agreement reached at that time between the management boards of the two units, details of all calls received on the CIMSU hotline in relation to acute chemical incidents occurring within the principality, however trivial, were required to be immediately drawn to the attention of staff of the National Focus, in order for them to be able to effectively fulfil their alerting and briefing role for Welsh Office. On a reciprocal basis, any calls received on the National Focus hotline relating to acute chemical incidents within the principality or which had been picked up by the media vigilance activities of Focus staff were to be immediately forwarded to CIMSU.

CIMSU

Number of Incidents

A total of 48 calls were received by CIMSU on their hotline during the period 1 February 1997 to 31 March 1998, of which 37 related to acute chemical incidents. The remainder mainly comprised of enquiries regarding the significance of chronic levels of pollution in the environment, for example, the potential health risks associated with residing close to areas of contaminated land or alleged clusters of illness in communities linked to controlled discharges from industry to the environment. Although outwith the scope of this thesis, there is evidence to suggest an increasing trend in the receipt of this type of enquiry by not only CIMSU, but the other 4 advisory and support units (including SCIEH) in the UK. If this is the case, then the Units are not currently resourced to handle this type of enquiry, which may be an issue for the National Focus to consider and raise with the Department of Health and, likewise, in relation to Wales, with Welsh Office.

Sources of Enquiry / Notification

Of the 37 calls received in relation to acute chemical incidents, the most frequent source was the unit with which CIMSU was co-located, that is, WNPU (N = 11). These all related to calls received by WNPU from Accident and Emergency Departments, who were in the process of providing medical care to those suffering from symptoms of exposure to chemical incidents. Eight calls were received respectively from local authority Environmental Health Departments, HA Departments of Public Health, and the National Focus, with two calls relating to local authority simulation exercises making up the total. Those incidents notified to CIMSU by the National Focus included 5 identified through media vigilance, 2 queries raised by Welsh Office from their own media vigilance, and 1 alert from the Health and Safety Executive.

Nature and Location of Incidents

The most frequently recorded types of incident were chemical spills (N = 16) and airborne releases (N = 10), followed by fires (N = 4) and explosions (N = 3). The remainder consisted of 1 potable water contamination incident, 1 food contamination incident and 2 incidents where there was no release. Incidents most commonly originated at operational industrial sites (N = 13), although only 2 at CIMAH sites, and at commercial premises (N = 5). The remainder included sewers (N = 3), educational establishments (N = 3) and open public spaces (N = 3). Only three incidents were transportation-related, 2 following road traffic accidents and the other on the railway. The latter had the potential to be a very major incident, involving the derailment of a tanker containing 60 tonnes of vinyl chloride monomer in a residential area. More than 1,000 residents were evacuated for 2 days, but fortunately there was no release.

Public Health Impact

There were no deaths attributed to the incidents recorded, and in 16 of the incidents, there were no people with symptoms. Of the remainder, only 4 resulted in symptoms in 5 or more people. The maximum number of people with symptoms in any one incident was 20.

Chemicals Involved

Thirty-five of the 37 incidents involved the release of a single chemical. In the other 2 incidents, 2 and 3 chemicals respectively were released. Asbestos, chlorine, ammonia, pesticides and petrol were those chemicals / chemical products most frequently released in the incidents recorded.

Nature of Advice Sought

In relation to 16 of the 28 incidents (the other nine calls to CIMSU were no more than notifications of incidents from the National Focus), advice was primarily sought by the caller on the hazardous properties of the chemicals involved, in order to support their risk assessment decisions at the time of the incident. The other main types of advice requested can be grouped as follows: medical toxicology, for the treatment of people with symptoms (N = 15); environmental sampling and monitoring (N = 15); biological sampling (N = 8); risk management (N = 7), for example, on the need for evacuation; environmental rehabilitation (N = 5); and epidemiology (N = 3).

Other Actions Taken

From the above analysis of the "sources of enquiry / notification" of incidents to CIMSU, it would appear that, in spite of the introduction of the "Welsh Health Circulars" in 1993, and the findings of the AWEHSP, CsCDC of HAs in Wales are still not involved in many of the incidents that occur within the principality. In the author's opinion, one of the most important roles that CIMSU has fulfilled in the past fourteen months is to immediately alert the relevant on-call CCDC to any acute chemical incident known to the unit to be occurring within their respective areas. This has served to galvanise CsCDC in Wales to get more involved with other local response agencies in the management of the public health aspects of acute chemical incidents, and also to enable them to do so armed with the relevant toxicological, environmental and public health advice.

National Focus

The roles of the National Focus, on being alerted to an acute chemical incident, are as outlined in Chapter 7. The 37 acute chemical incidents that have occurred in Wales over the past fourteen months represent exactly 37% of the 100 incidents reported to the National Focus from all sources in the UK during this period (primarily notified by the five advisory and support units). The main role of the National Focus in relation to the incidents in Wales has been to consider the likely political ramifications of each for the Welsh Office Health Department, and where necessary, to alert and provide written briefings for the use of their public health professionals and media liaison officers. In this respect, the National Focus has alerted Welsh Office to 22 of the 37 incidents, and provided written briefings in relation to 12 of the incidents.

One of the other roles of the National Focus' chemical incidents telephone hotline is to act as a back-up resource to the front-line role of CIMSU, should the latter not be contactable or advice is required above and beyond that available from the unit. Over the fourteen month period under evaluation, no such calls were received on the National Focus hotline, suggesting the effective operation of the CIMSU hotline and the satisfaction of callers with the advice received.

Relationships with other Advisory and Support Units

The Future of CIMSU

In the author's opinion, one of the biggest threats to the future of the existing model in Wales is the sustainability of CIMSU. In having to compete in the marketplace for contracts with HAs, including those in Wales, the unit has a very low income base. On 1 April 1997, CIMSU held contracts with 5 Health Authorities (£3000 each) and 19 local authorities in Wales and England (£1200 each), enabling the employment of just 1 full-time dedicated member of staff. Although the situation has improved slightly with additional contracts having been negotiated with other local authorities in Wales and with the 4 health boards in Northern Ireland, this member of staff has been on call 24 hours a day, 365 days a year for the last fourteen months, which is untenable.

Additional pressure is placed on CIMSU by the fact that all the contracts are renewable on an annual basis, which means that there is little security of tenure for the current member of staff or any likelihood of attracting new members of staff to the unit. Already, there is anecdotal evidence of a competitive marketing strategy by one of the other advisory and support units in relation to the contracts held by CIMSU with local authority Environmental Health Departments.

This is where the author's preferred model, which was outlined in Chapter 7, would have benefited the smaller units, such as CIMSU. With contracts of at least three years' duration and a more equitable distribution of contracting HAs per unit, CIMSU and likewise the other three units in England would each have had a sustainable resource base. As it now stands, CIMSU will continue to be under threat from the retention of the market model of health service provision.

Handling of Cross-Boundary Incidents

The other issue of concern, with respect to the market model of health service provision, was that competition between the four advisory and support units might not lead to harmonised working in the event of an incident crossing the boundary between the respective operational areas of two separate units. For example, if an explosion and fire was to occur today in Avonmouth, Bristol and the resulting smoke plume was to drift across the River Severn to Gwent in Wales, the Chemical Incident Response Service, London would provide advice and support to Avon HA, and CIMSU likewise to Gwent HA. However, there would be an additional complication, in that CIMSU also holds a contract with the Environmental Health Department of Bristol City Council, whose jurisdiction lies within the area of Avon HA.

This is therefore where the coordinating role of the National Focus comes into effect. Since 1 February 1997, the National Focus has generally built up good, working relationships with all four of the advisory and support units in England and Wales, and also SCIEH in Scotland, and now chairs a regular meeting with the "Heads" of these units. Under consideration at the next meeting of this group will be the need to formulate plans for the handling of cross-regional incidents, where more than one unit may be involved. As part of this process, discussions will also be held on the benefits of securing improved harmonisation of the information contained within the chemical data sheets issued by the various units, in incident management situations.

Surveillance

The National Focus was also given responsibility on 1 February 1997 for the development and maintenance of a national surveillance system for acute chemical incidents in the UK. This was intended to build on the experiences of the All Wales Environmental Health Surveillance Project (AWEHSP) and those of other systems that had subsequently evolved in the NHS (West Midlands) Region and in Scotland. To guide this programme of activity, the National Focus has therefore during the past year:

(a) undertaken a systematic review and evaluation of existing surveillance systems in the UK and overseas. A number of systems were identified, including examples of good practice. However, none afforded complete coverage of the UK, and their status varied from fully operational to pilot systems; and

(b) convened a working group of all interested parties to discuss and reach agreement on: (a) the aims and objectives of any proposed surveillance system; (b) the minimum dataset required; (c) the reporting formats to be used; and (d) the most appropriate mechanisms for data reporting, analysis and dissemination of lessons learned. Those participating in the working group discussions have included representatives from each of the five advisory and support units in the UK (incl. CIMSU), the Ambulance Services Association, National Chemical Emergency Centre, Health and Safety Executive, Environment Agency, Marine Pollution Control Unit, the NHS (Yorkshire and Northern) Region and Welsh Office.

Key features of the proposed surveillance system include:

(a) the development of multi-agency surveillance systems by each of the five advisory and support units; in this respect, CIMSU is progressing well with the evolution of a system for Wales;

(b) the monthly submission of an agreed minimum data set to the National Focus;

(c) the analysis of data and dissemination of regular reports to an agreed distribution list;

(d) the cross-referencing of incidents to reports received from other national sources, for example, the National Chemical Emergency Centre, to evaluate the sensitivity and validity of the national and regional systems developed; and

(e) the provision of a sub-set of the national data to the WHO Collaborating Centre for an International Clearing House for Major Chemical Incidents, Cardiff.

On 1 April 1998, the Department of Health Steering Group gave their approval for the surveillance system to be piloted over the next 12 months.

The National Focus has also developed, in association with the Ambulance Services Association, a surveillance system for the reporting of acute chemical incidents by ambulance service trusts in the United Kingdom. The aims of the project, which is being funded by the Department of Health's Emergency Planning Co-ordination Unit, are: (a) to increase awareness of ambulance services personnel to the hazards arising from response to acute chemical incidents; (b) to review the effectiveness of decontamination and personal protection procedures employed by ambulance services personnel in responding to chemical incidents; and (c) to guide the development of appropriate training materials, methodologies and courses for ambulance services personnel and others working within the NHS. Surveillance of acute chemical incidents for this project will again commence on 1 April 1998.

Emergency Planning

Both CIMSU and the National Focus targeted emergency planning as one of their respective key areas of activity during the past fourteen months. In this respect, the "Heads" of each of the units have been fully involved in supporting the Welsh Collaboration for Health and Environment in the development of a "Model Plan for dealing with Acute Chemical Incidents in Wales". This was officially launched on 11 June 1998.

On a similar theme, in April 1997, the National Focus was asked by the Department of Health's Emergency Planning Co-ordination Unit (EPCU) to take the project lead on the revision of Chapter 9 - Health Service Arrangements for Dealing with Chemical Incidents, as part of a fundamental review of major incident guidance in the NHS. It is anticipated that a draft version of the completed guidance will be issued for wider consultation within the next few months, with a view to publication later in the year. The Chapter will also be adapted for Welsh Office.

Staff of the National Focus have also represented the Department of Health on two consultative committees of the Health and Safety Executive, established to consider strategies for the implementation of the new Control of Major Accident Hazards (COMAH) Directive; and also on various consultative fora and technical groups of the Coastguard Agency, which is currently revising the "National Contingency Plan for Pollution from Shipping and Offshore Installations".

Training

As part of its contractual obligations to subscribing authorities, CIMSU has developed and run two desktop exercises during the past fourteen months. Both were well received by the target audiences, and it was encouraging to see a mix of CsCDC and Environmental Health Officers at the training days. The National Focus was involved in an observer capacity for the first of the two training days.

The role of the National Focus is to provide information on relevant available training and to promote the development of further suitable training, if needed. In this respect, the National Focus has just completed a "training analysis review" of courses, methodologies and materials currently available to the health sector both in the UK and overseas, where the content of all or part of the syllabi relate to public health aspects of the management of chemical incidents.

The review will then provide a basis for discussion over the forthcoming year with the professional faculties and other interested parties towards the development, where necessary, of a range of accredited courses, materials and methodologies for CsCDC and other health professionals both within and outwith the NHS.

From 9-11 March 1998, the National Focus also hosted, in collaboration with the WHO Collaborating Centre for an International Clearing House for Major Chemical Incidents and the International Programme on Chemical Safety, an "International Training Conference on Chemical Incidents" . The aim of the Conference was to highlight the importance of improved inter-agency working to protect the health of emergency responders and the public. Held in Cardiff, the Conference attracted over 100 delegates from a range of disciplines and agencies.

Best Practice Protocols

Two areas of activity have been identified, to date, for the development of best practice protocols: (a) the need for criteria to guide decisions on the likely efficacy of conducting epidemiological follow-up of a particular chemical incident, and (b) guidance on how to communicate risk to the public / media at the time of a chemical incident. These will be taken forward as part of the work programme for 1998 / 1999.

HAGCCI Secretariat and Activation

In June 1997, the Department of Health passed responsibility for activation of the HAGCCI advisory system to the National Focus. Since that time, no calls have been received from any of the 5 DsPH of HAs in Wales or from the Chief Medical Officer for Wales requesting activation. Likewise, no such requests have been received from similar professionals in England, Scotland or Northern Ireland. With the advent of the various support and advisory units, together with the coordinating function of the National Focus, it may be that the HAGCCI advisory system is no longer required. In this respect, the National Focus has been asked, as part of its work programme for 1998/1999, to review the existing system in light of current developments, and to make appropriate recommendations for the consideration of the four government health departments (including Welsh Office), and the three standing members of the HAGCCI core panel.

Better Health, Better Wales

Finally, both CIMSU and the National Focus have contributed to the Welsh Office's green paper on "Better Health, Better Wales", which states that:

> ... A number of organisations will also provide the National Assembly for Wales with excellent resources to ensure that Wales manages well the health aspects of emergency and long-term incidents involving dangerous substances. These include the *National Focus for Chemical Incidents ...* and the *Chemical incident Management Support Unit.*
>
> (Welsh Office 1998)

Chapter 9 - Conclusions and Recommendations

In answer to the original aim of the project, the establishment of a national coordinating and a regional advisory and support structure for dealing with acute chemical incidents was considered to be warranted for Wales and accordingly, a public health management model was developed for its provision. The model has been in place since 1 February 1997. It is therefore too early to draw any definitive conclusions regarding its utility, but in its first fourteen months of operation, the model has made a constructive contribution to the enhancement of local and national arrangements for the public health management of acute chemical incidents within the principality.

This is important, as advances in chemical technology will continue to occur in Wales, as they will in all parts of the world. As demonstrated by the results of the All Wales Environmental Health Surveillance Project, and the review of the first fourteen months of activity of the public health management model, in spite of improved prevention and state of the art safety management systems in industry, inadvertent chemical releases are still common occurrences in Wales. Although most do not give rise to any harm to human health or the environment, public health professionals are invariably faced with problematic health risk assessments from an increasingly informed and concerned public. Ensuring that such professionals have access to the best advice available on a 24 hours a day, 365 days a year basis is therefore critical. This, in essence, is the rationale behind the model that has been developed.

As anticipated at the outset, an important factor in the very completion of this research was the decision taken to seek solutions, at all stages, to the potential barriers that might exist in effecting implementation of any model developed, by both public health policy and decision makers. One of the major obstacles to progress was in overcoming the narrow view held by the traditional emergency responders of the role of public health in the management of acute chemical incidents. In the author's opinion, this may partly be explained by the evolution of definitions and conceptual models of public health. Although characterised by a wealth of intellectual traditions, the field is still over-shadowed by clinical medicine and biomedical research. Allied with lack of powers, resources and training in the field of non-communicable environmental hazards, such public health professionals have in the past been unable to undertake the necessary inter-sectoral collaboration to break into the classical command and control structure of incident management.

The downside of seeking solutions to such perceived barriers was that the research was very often guided by the politics of the National Health Service (NHS) and of the three health interest groups: the professional monopolisers, the corporate rationalisers and the community interest. The path the research has followed has therefore taken many different turns, which have been recounted in previous chapters.

With the occurrence of acute chemical incidents such as aluminium contamination of water supplies at Lowermoor and the sudden emergence of a cluster of cases of aplastic anaemia in children in Cardiff, it was understandable that the Department of Health and Welsh Office had to be seen to be addressing public concerns about environmental hazards. In response, they therefore increased the roles and responsibilities of health authorities, and made the latter more accountable for the protection of the health of populations potentially exposed to chemical hazards within their respective areas. In Wales, the Welsh Office quite rightly recognised that in doing so, they needed to better define the size of the problem of acute chemical incidents within the principality and also attempt to identify the additional expertise and resource requirements of public health professionals involved in the management of such incidents.

Given the limitations of chemical incident database resources for this type of evaluation and the general paucity of data on acute chemical incidents in the scientific literature, the only way to achieve these objectives was to develop a surveillance system.

The All Wales Environmental Health Surveillance Project (AWEHSP) was the first active, geographically defined, community-based surveillance system to be set up in Europe, and has clearly demonstrated that relevant data on acute chemical incidents can be collected, collated and analysed to guide the actions of public health policy makers. The benefits of a multi-agency surveillance system were also highlighted, with little overlap in the incidents reported by the various reporting agencies.

The AWEHSP showed that acute chemical incidents were common in Wales. A total of 642 incidents were reported from all sources over the three year duration of the project. Of the 270 incidents reported by local authority Environmental Health Departments, most were chemical spills (28%) or airborne releases (22%), and 75% occurred outside operational industrial premises. A total of 237,991 people were exposed in the 214 incidents for which information was available, although few suffered symptoms (528 people in 57 incidents). A single chemical was implicated in 86% of releases. An integrated emergency management approach was largely adopted, with inter-sectoral collaboration between many different agencies, dependent on the nature of the incident. However, in only 10% of incidents was there any health authority involvement, suggesting that, even with the prescription of new roles and responsibilities, Consultants in Communicable Disease Control (CsCDC) were still not being alerted, or taking part in the response to incidents. A further issue of relevance to health authorities was that in only one of the 270 incidents reported was any kind of formal epidemiological follow-up undertaken.

The usefulness and cost-effectiveness of the AWEHSP was also clearly demonstrated, but whilst the system exhibited qualities of simplicity and flexibility, there were concerns regarding the sensitivity and specificity of the "definition of an incident" used, the acceptability and timeliness of the system, and the representativeness of the data collected. These should be taken forward as lessons in the development of any future surveillance systems, including that proposed by the National Focus within its current work programme.

The AWEHSP concluded that, based on the results of the surveillance system and the outcomes of discussions held with individual reporting officers, and delegates at a two-day conference, that consideration should be given to the development of a centralised advisory and support unit to complement the activities of the Welsh National Poisons Unit (WNPU), in providing assistance to public health professionals in Wales in managing acute chemical incidents.

The preferred evolution of that system would have been as a developmental project for Wales, and possibly the NHS (South and West) Region (the latter on the basis that the WNPU was already contracted by the Department of Health to provide medical management advice to health professionals within the Region). However, the marketplace politics of the NHS and the increasing presence of other professionals with expertise to offer in the field meant that the Department of Health, supported by Welsh Office and the other two government health departments, had to take a strategic view of the situation, both to ensure that they had access to the best available advice to discharge their own responsibilities and to bring some coordination to any network of support that was developed.

In the author's opinion, the conduct of the "Study of Activity on Public Health Effects of Environmental Chemicals in the Environment" was the right way forward, as it ensured that all relevant parties, both within and outwith the NHS, had an opportunity to express their concerns and opinions on the gaps in current provision and on the nature of any model that was to be developed. However, the final model chosen was not the author's preferred model. There was agreement between the latter model and the one selected that the primary health service responsibility should rest at the local level, in line with national policy on emergency planning. There was also agreement that there was a need for a national, coordinating centre: (a) to act as a source of alerting and briefing to the Department of Health, Welsh Office etc., (b) to coordinate and harmonise the activities of the five advisory and support units, and (c) to provide the necessary evidence-base for the public health management of acute chemical incidents through programmes of surveillance, training, and emergency planning, and best practice protocol development. The difference of opinion was in leaving the contracting of advisory and support units by health authorities to the marketplace. In the preferred model, there would have be an equitable distribution of fee-paying health authorities, based on NHS Regions in England and Wales as a whole, between the four emerging units. This model would have been retained for a period of three years to guarantee the sustainability of the units and to encourage harmonised working, under the coordinating umbrella of the national centre.

In contrast, the model selected left this aspect to the marketplace, resulting in the rapid monopolisation of 6 out of the 8 regions in England by one unit, and concerns over potential difficulties in these now competitive units working together in the event of a cross-regional incident. These are matters currently being addressed by the National Focus.

With respect to the model in Wales, there are concerns regarding the future sustainability of the Chemical Incident Management Support Unit (CIMSU), given its small share of the market. However, during the past fourteen months, the unit has operated very effectively in the performance of both its reactive incident support roles and proactively, with respect to emergency planning, surveillance and training. Likewise, the National Focus has met all of its targets for year 1, as measured against the work programme set by the Department of Health Steering Group.

The research has therefore achieved the aim set in the introduction. Only one recommendation is made and that is for a full evaluation of the selected model to be performed at the end of three years.

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